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Fall Glass Division Meeting — a review of papers and discussions

● The Fall Glass Division Meeting was held at the Bedford Springs Hotel, Bedford, Pennsylvania, on Thursday and Friday, October 11 and 12. Registration was approximately 300, of whom about 50 were accompanied by their wives.

The program committee composed of Frank R. Bacon, Owen-Illinois Glass Co.; J. R. Hensler, Bausch & Lomb Optical Co., and Ralph K. Day, Libbey-Owens-Ford Glass Co., provided an exceptionally good program that was well balanced between fundamental and practical papers. The program committee was ably assisted by Scott Anderson, Anderson Physical Laboratory, Champaign, Illinois, who arranged a panel discussion, "The Surface Chemistry of Glass" for the Friday morning session.

Frank R. Bacon was chairman of the initial session on Thursday morning and the first report was "Comments on the 1956 Gordon Conference on Glass" by O. L. Anderson, Bell Telephone Laboratories, Murray Hill, N. J. The report was ably presented by Harrison Davies, Mellon Institute, because of illness of Mr. Anderson.

Mr. Davies summarized the various technical papers presented at the Second Gordon Conference on glass which was held at the Kimball Union Academy, Meriden, New Hampshire, during the week of August 26. These papers were devoted primarily to "Strength of Glass" and various aspects of the "Surface Chemistry of Glass" The subject "Strength of Glass" was theoretically treated by Professors Poncelet of Stanford Research Institute and professor Orowan of the Massachusetts Institute of Technology. While their theories were not always in agreement, nevertheless, many benefits were gleaned from such discussions. The important role and use of electron microscopy was emphasized and many pictures were shown. Dr. Frank N. Preston was Honorary Chairman of the conference.

The subject of "Surface Chemistry of Glass" was ably treated by R. K. Iler, duPont Company, and B. J. Todd, Corning Glass Works. Mr. Iler considered the surfaces of silica and various silicates when exposed to aqueous films, while Todd presented experimental data concerning the migration of water from the interior to the surface of glass.

The advantages of technical and theoretical discussion in the unrestrained and yet friendly atmosphere of the Gordon Conference were pointed out. Plans are being made for a third conference next summer and numerous subjects are under consideration. Mr. Davies has been elected chairman for the coming year. Much benefit is derived from such sessions and it is hoped that those having technical responsibilities in the glass industry will be anxious to support future conferences.

The next paper, "The Nature of Acid Attack on Soda-Lime-Silica Glasses," by Joseph L. Pentecost and F. V. Tooley, University of Illinois, Urbana, Illinois, was presented by Mr. Pentecost. This interesting paper represented the results of research submitted by Mr. Pentecost in partial fulfillment for the degree of Doctor of Philosophy at the University of Illinois. A study was made of the nature of acid attack on simple soda-lime-silica glasses by analyzing quantitatively the products of the reaction during different stages of attack.

Three glasses of systematically varied composition were reacted with water, HCl, H_2SO4 and tartaric acid for time periods of one-half, one and three hours. A constant temperature of 90° C. was used for all experiments. A standard powder method was used except that the resulting extracts were analyzed chemically for sodium, calcium and silicon. The sodium was determined by flame photometry; calcium by a versenate titration; and silicon by the silico-molybdate blue method. The results were presented as rate of ion removal curves and were further utilized to calculate the excess sodium and excess calcium ion numbers. These numbers were used as an index of the extent to which ion exchange preceded the network breakdown reaction.

Two major types of attack were noted. With water the predominant attack meachnism was a complete breakdown of the glass network, while with acid concentrations greater than 0.02 N, ion exchange was the predominant reaction. The more durable glass evidenced acid attack at lower acid concentration than did the less durable glass. The removal of calcium from a glass by ion exchange was found more dependent on the soda-calcia ratio than the calcium content of the glass for the range of compositions studied. The high calcia glass showed less calcium and sodium removal with acid attack than with water attack, while the high soda glasses exhibited a greater rate of removal of these ions with acid attack.

When acids such as HC1, H_2SO4 and tartaric in concentrations of 0.02 N or higher attack glass, sodium and calcium ions diffiuse from the glass into the solution, while H_3O+ ions diffuse into the glass. This type of attack results in a partially hydrated silica-rich surface layer, bonded tightly into the glass structure.

The excess ion number was found extremely useful in evaluating rate of ion removal data on the basis of the type of attack mechanisms.

The next paper was, "Effect of Platinum in Simple Lead Glasses." R. J. Ryder and G. E. Rindone, Pennsylvania State University, University Park, Pennsylvania. This paper was presented by R. J. Ryder. The colorations brought about by platinum were studied in various type glasses. This problem has considerable practical significance since platinum is being used more extensively each day in the melting of optical glass and glass fibers. Off colors have been noted in various melts and especially trends toward yellow coloration.

The colors produced were studied by means of transmittance curves and several excellent color slides were shown. The colors produced were shown to be predominently gray with borate glasses and yellow to red with phosphate glasses.

Attempts were made to explain the various colors on the basis of chloro-platinic reactions in glass which are susceptible to oxidizing and reducing conditions. Ceriun hydrate was especially effective in controlling some of these reactions. It was also shown that under neutral or reducing conditions gray colors were produced by as little as 10 ppm. of platinum and light scattering occurred at as little as 5 ppm. of platinum.

The next paper, "A Frictional Study of Silicones as Glass Lubricants" was given by C. W. West and T. J. Mahoney. This paper was a contribution from the Silicones Division, Union Carbide & Carbon Corporation, Tonawanda, New York.

Surface abrasion occurs when glass objects rub against one another and such deterioration may take place during handling, processing and shipping. Such abrasion is known to have a detrimental effect on the strength of glass and may result in a marring of the surface and appearance of the product. It is believed that the cleaner the surface, the greater the possibility of seizure. Actually, the most crucial time or likely period of deterioration may be immediately after its formation when the surface is cleanest. With the passage of time, pick-up of contaminants from the surroundings will reduce the possibility of seizure. It is well established that coatings are known to be beneficial and the application of coatings and lubricants has been practiced for many years and is known to be useful in the retarding of abrasive action.

The details of a modified frictional and abrading test were given and the benefits of a number of useful coatings were shown.

The procedure can be modified to study the influence of other pertinent variables on the lubricity afforded by antiseize materials. For example, the surface temperature at which the lubricant is sprayed, the cure temperature, and the effect of varying the surface concentration of antiseize material could be studied.

A number of silicones provide favorable lubrication for glass under boundary conditions. Modification of the conventional silicone molecule affords still better lubricity as shown by the frictional data for "Union Carbide" X-520 organo-silicone co-polymer.

These studies also demonstrate that static-friction measurements in conjunction with the techniques employed for preparing and treating the glass specimens do serve to indicate appreciable differences in lubricity among materials evaluated for use in glass technology.

The next paper was "Structure of Neutron Irradiated Quartz and Vitreous Silica," by Ivan Simon, Arthur D. Little, Inc., Cambridge, Mass.

Mr. Simon presented results of a fundamental nature sponsored by the Owens-Illinois Glass Company at the research laboratories of the Arthur D. Little, Inc.

Neutron irradiations of both quartz and vitreous silica were made by various exposures and then alterations in structure were ascertained by the analysis of X-ray diffractions made of the variously irradiated samples. Maximum dosage was reached in a few weeks. Because the X-ray patterns of amorphous materials are diffuse and indistinct, halos of a Fourier method of analysis was used. The Fourier analysis was greatly aided and the accuracy and speed of the analysis was greatly improved by the use of electronic computers. The computers completed analysis in approximately 35 minutes that otherwise may have required 5 to 6 days of laborious calculations.

The irradiation technique is believed to show considerable promise and changes in structure were believed to be similar to that brought about by the addition of Na_2O to SiO_2. The change was also explained as being one similar to that brought about by atomic fusion followed by extremely rapid cooling under pressure. Variability of bond angles in the structure was emphasized.

Now that more accurate and less-laborious procedures are available for analysis, it is hoped that these techniques may find greater application.

"Report on the International Congress on Glass," was a summary capably given by C. L. Babcock, Owens-Illinois, incorporating the highlights of the recent International Congress on Glass held in Paris, France, July 2-4.

The program following this three day meeting was given and the various technical papers (53 in number) were outlined. English, French, and German were the three official languages. The splendid work of the interpreters was lauded as their efforts aided the comprehension of the papers.

The program was divided into 8 different sessions and papers related to viscosity, strength, equilibrium diagrams, etc. presented many challenging questions.

Mr. Babcock's summary was very interesting and informative.

The Friday morning session was devoted entirely to a panel discussion, "The Surface Chemistry of Glass." The session was well guided by Scott Anderson, Anderson Physical Laboratory, Champaign, Illinois, who acted as moderator.

The first speaker, Woldemar A. Weyl, Pennsylvania State University, University Park, Pennsylvania, confined his remarks to the structural aspects of glass as influencing the chemistry of the surface.

Because X-ray techniques do not give the complete picture of the structure and constitution of glass, Weyl and his co-workers at the Pennsylvania State University have developed an atomistic approach to the problem. The attack by acids was pictured as a penetration of proton into an anion. The rate of proton penetration is influenced greatly by its environment and consequently the chemical composition of glasses assumes great importance. The recent work of Kreidl and others with the use of tantalum in optical glass was cited as an example of such environmental influence.

The lowering of the liquidus by the addition of such alkali ions as Li^+, Na^+, K^+, Rb^+, Cs^+ was pointed out as further evidence of the extreme influence of environment on glass formation. The continued addition of such ions ultimately cause a complete breakdown of the glassy structure.

The fact was also emphasized that such reactions are rate phenomena and the rate of reaction must be considered.

The next speaker on the panel was Martin E. Nordberg, Corning Glass Works, Corning, N. Y. Mr. Nordberg dwelt at some length on the reactions between sulphur dioxide (SO_2) and glass surfaces. It is a well known fact that exposure of glass to sulphur dioxide gas in the annealing lehr improves the durability. The improvement in durability is believed to be due to a depletion of the glass surface of Na_2O accompanied by a "compacting" of the surface.

Tests were described in which carefully prepared glass samples were treated with SO_2 gas in a test furnace. Such factors as temperature, atmosphere and flow of gas were all specifically controlled. The various factors of sample condition (preparation), temperature control and flow of gas and atmosphere were considered as being the most important variables to control. The extraction of Na^+ was shown to vary with time of treatment and increase with temperature.

Durability was measured by Na_2O extractions after specific treatment. It was found that as Na_2O was removed the durability was improved but the amount of surface compaction was also a contributing factor.

Considerable discussion followed this paper especially in regard to the migration of Na^+ ions to the surface and the effects of water both at the surface and within the glass. Various sample preparations were considered and chromic acid washing was found to hasten the formation of "bloom" during the gas treatment. The rapid formation of "bloom" was believed to be associated with the migration of Na^+ ions to the surfaces.

The third speaker on the panel discussion was F. C. Raggon, Owens-Illinois Glass Co., Toledo, Ohio. Mr. Raggon emphasized the important fact that glass containers are called upon to withstand the action of a variety of chemicals such as alkaloids, adrenalin, strychnine, blood plasma, alcohols, and a variety of pharmaceuticals. It was shown for example that sodium citrate was more corrosive than water. Other materials such as tartrates, oxalates, gluconates, fluorides, malates and ascorbates are also believed to be more corrosive than water.

A variety of curves were shown indicating the content of extracts from glass due to various corrosive agents. After exposure to action by water SiO_2 was the greatest to be extracted followed by Na_2O and CaO. On the other hand when acids were used as the corrosive agent Na_2O was the greatest to be extracted followed by SiO_2 and CaO. The action of alkaline solutions as well as various buffered solutions were also considered.

The most important factors considered in relation to container durability were: glass composition, thermal history especially as it effects the surface of the container, composition of atmosphere around the surface of the container as it is formed and composition of lehr atmosphere. Dry air in the lehr is known to improve durability while moist air in the lehr is known to cause a reverse effect.

This discussion emphasized the importance of selecting the proper test in order to evaluate containers for specific uses.

The final speaker on the panel was H. E. Simpson, State University of New York, College of Ceramics, Alfred, N. Y. Mr. Simpson confined his remarks to the effects of water or moisture on the surface of glass, particularly as evidenced by atmospheric corrosion and weathering.

Cyclic humidity tests, were described which have been useful in the evaluation of ground and polished plate glass, fire-polished window glass, optical reticules, ranging from optical crown glass to heavy flint glasses and various container and bottle glasses. The breakdown of these glasses were measured by means of a haze meter. The haze meter measures, by means of a photoelectric cell, the total transmission of the sample and the amount of scattered light and the relative amount of scattering is taken as a measure of haze or surface deterioration. In the case of studying the deterioration of curved surfaces of the container glasses, a replication of the surface was necessary in order to adapt the haze meter technique of measurement. Successful plastic replicas were made by means of solutions of Vinylite and ketone. By plotting the percent haze versus exposure time characteristic curves for different types of glasses were produced. This type of information has been shown to be useful in evaluating the surface durability of various glass products. Some excellent electron micrographs showing various stages of deterioration of the glass surfaces were shown. These micrographs were prepared by J. G. Sayre, Owens-Corning Fiberglas Corp., Newark, Ohio, and C. W. Milton, Battelle Memorial Institute, Columbus, Ohio. Marked differences were noted in the various type glasses studied and the superior resistance of alumina-bearing glasses and flint glasses (lead) were quite evident. The combined method of first deteriorating a glass surface under cyclic-humidity exposure followed by a study utilizing electron microscopy appears to offer an interesting method of studying surface chemistry of glass.

The panel presentation offered an opportunity for ex-

tensive discussion and Mr. Anderson is to be congratulated on organizing an excellent panel.

The first paper in the Friday afternoon session was "Micro-Area Tensile Strength of Glass Fibers by Cross-Bending." Albert H. Lasday and Richard E. Mould, Preston Laboratories, Butler, Pennsylvania. The paper was presented by Mr. Lasday. Cross-bending strengths of glass fibers were determined in a special apparatus designed to handle fibers approximately 1.2—2.2 mils. in diameter. The fibers were pulsed and if no fracture occurred they were pulsed again until fracture was accomplished. The duration of loading was about .01 second. The results of strength tests of several types of fibers were as follows:

	E Glass	C Glass	F Glass
Maximum (psi)	702,000	570,000	389,000
Minimum (psi)	680,000	552,000	378,000

The difference between maximum and minimum was about 3 per cent. The significant fact of interest is that this method of testing shows marked differences between the different types of glasses studied.

In discussion it was pointed out that little study could be made of the types of fracture obtained because the fibers were mutilated in testing. The span of breakage is extremely small and although care was used in drawing the fibers (drawing through paraffin) it appeared to make little difference in their strengths whether the paraffin coating was removed or not prior to fracture. The method appears to be a most hopeful one for studying strengths of glass fibers.

The next paper was "Compaction Effects in Glass Fibers". "Compaction" was described as the process by which glass fibers become denser at a temperature below the normal annealing range. This phenomenon is characterized by changes in physical properties from those normally expected when the same glass has been properly annealed.

It is reasonable to believe that the condition represents a state of equilibrium frozen in at some higher temperature. On reheating, the fiber will change in length contracting rapidly at first and then slower until some stabilizing temperature is reached.

The compaction appears to be equal or the same in all directions. The balanced stress to prevent contraction is estimated to be about 9,000 lbs. per square inch.

The structure retained is said to be typical of some higher temperature and upon cooling the equilibrium condition cannot keep pace with the cooling rate but on reheating to some stabilizing temperature the properties of the newly treated glass return to those characterized by some lower temperature.

Compaction is a common characteristic of rapidly cooled glass fibers.

The next paper was "Further Studies of Glass With the Electron Microscope," by J. W. Michener and J. G. Sayre, Owens-Corning Fiberglas Corp., Newark, Ohio. The paper was presented by Mr. Michener. "Micellar" structure or regions of a high-degree of order surrounded by areas of a less degree of order have been seen in C-glass, E-glass and lead glasses. X-ray diffraction patterns were made of those areas showing "Micellar" structure and the diffraction patterns were very indistinct halos indicating a glassy structure. Areas of known crystallization on the other hand showed a definite and specific X-ray pattern.

Attempts were made to follow the genesis of crystallization of some sodium silicate glasses by means of a platinum liquidus-boat. In view of X-ray studies, these glasses did not show crystallization. No explanation was given for the results, but it was suggested that water pick-up of these type-glasses may have influenced the results. It was also pointed out that the compositions were close to the sodium disilicate composition which may have developed the "micellar" structure to a high degree.

The next paper, "The Direct Production of High Melting" by Alexander Silverman, University of Pittsburgh, Pittsburgh, Penna., was a practical one related to the production of glass fibers. A method was described for the direct production of glass fibers. The raw material was introduced at the top of a vertical cascade type furnace in the form of extruded rods. In order to attain extremely high melting temperatures, acetylene and oxygen were used in Selas type burners. The rod-type extruded batch was bonded with clay or sodium silicate. Metal wires such as aluminum and magnesium were also incorporated in the batch. This provided a means of introducing this element into the glass and at the same time, advantage was taken of the exothermic reaction involved in their oxidation.

Both bulk fibers as well as drawn fibers were made. Excellent fibers have been made consisting of CaO, Al_2O_3, ZrO_2, and SiO_2 and they have found application in the aircraft industry.

Zirconia refractories have proven successful in the hotter portions of the furnace and copper-tipped burners of the Selas type have been successfully used for burning the oxyacetylene fuel.

The next paper was, "Spectrophotometric Quality Control of Welding Glass Density." This paper was a very practical one and R. H. Peckham of Pennsylvania Optical Company, Reading, Pa., showed a most useful means of evaluating welding glasses. It was possible by means of the data collected to determine the thickness limits of each glass for a desired shade to be used in welding operations. This information thus served as a basis of operation for the production department. The glasses used were of various types; however, those involving iron, neodymium, cobalt (blue), chromium (green), were the more important.

By means of the spectrophotometer the produced glasses could be inspected and undesirable shades discarded, hence the technique was of invaluable assistance to the inspection department. The procedure has enabled the strict inspection of a product that otherwise might be subject to considerable personal variations in inspection.

The next paper was, "A Note on the Transmittance of Amber Bottle Glass," by K. C. Lyon, Ball Bros. Co., Muncie, Indiana. This paper was a treatment of published data related to the transmittance of various iron containing amber glasses. Various references were cited and data was taken from published work of Holscher and others.

Because the transmittance at 550 mircons wave length and 2 mm. thickness has special significance in amber glass manufacture this reference point was taken as a basis of comparison.

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Cords In Glass

By M. A. KNIGHT

Part III

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SECTION II. FACTORY PRACTICE RELATING TO CORDS

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IF. Mechanical Strength

Three routine tests are available for the detection and evaluation of severe tension cords in glass containers, namely, polariscopic examination, the internal pressure test, and the thermal shock test. In the first of these, the presence or absence of cord may be directly observed. The other two tests yield indirect evidence of the presence of severe tensions in specific regions of the container, but these two are sensitive also to other, non-cord defects in the ware. Examination of ware in air and immersion polariscopes gives considerable information about the cordiness of the ware. However, ring sections give still more information.

The resistance of bottles to internal pressure may be affected by severe outside-surface tension cords in the shoulder area. The effect of such cords in this area may be estimated best by running the internal pressure tests at pressures well above those in the usual "pass test" of the ASTM standard method (1950a).

Outside-surface tension in the heel and the base of the bottle is best detected by the thermal shock test. The ASTM standard method (1950c) recommends a temperature difference of 75°F between the hot and cold baths in the "pass test". However, the temperature differential that a good bottle should sustain depends to some extent upon the type of bottle and its design, as well as upon the service conditions which it will encounter in use. While defects of appearance can be detected by visual inspection of the ware as it is packed, most of the defects that affect mechanical strength can be revealed only by adequate testing. An exception is the presence of such severe, outside-surface tension that cracks or splitting and chipping occur spontaneously or when the area is scratched with a hard point.

IG. Fluorescence

Some substances absorb radiant energy of a specific wave length and re-emit the energy as radiation of longer wave length. The phenomenon is known as fluorescence. Ordinary commercial soda-lime-silica glasses show pale grayish fluorescence under ultraviolet radiation (Gilard et al 1938; Grant 1938). Bezborodov and Abelchuk (1938) state that when such glasses are contaminated by the products of attack upon aluminous refractories, the resulting cords show a yellowish-brown fluorescence. On the other hand, pure silica contamination does not change the color of the fluorescence appreciably.

IH. Chemical Durability

Because the chemical composition of cordy glass differs from point to point, the surface of the glass offers a varied resistance to chemical attack. Thus, areas rich in alkali have a lowered chemical durability, whereas in areas rich in alumina or lime the durability is increased. In general these differences do not help materially in cord diagnosis, for the surface of glass of even the best commercial quality may exhibit an unexpectedly large variability in resistance if the chemical attack is of long duration. This is shown by the patterns of parallel ridges and grooves which may be raised on the glass surface by prolonged etching with water vapor at atmospheric pressure. Such patterns apparently outline the flow movements of the molten glass during the final forming operations. Nevertheless, in the case of cords due to refractory attack, the short-term resistance to dilute hydrofluoric and sulfuric acid can be used to differentiate between alumina and silica contamination, as suggested by Coe (1949) and Taylor and Hill (1952).

IJ. Reduction-Oxidation Properties

The reduction-oxidation (redox) state of a glass sample depends both on the chemical elements in the glass and on the firing conditions under which it was formed. The state of the sample as a whole can be determined by melting it in various furnace atmospheres. Day and Silverman (1942) studied reactions between iron and selenium in soda-lime-silica and potash-soda-lime-silica glasses melted in air, nitrogen, and carbon monoxide atmospheres. The electrolysis method described by Rindone, Marboe, and Weyl (1947) in which the glass is melted under the influence of known electrical potentials impressed on the melts by electrodes, permits a still wider range of con-

The complete bibliography covering all four installments of this paper was published in the September issue.

Dr. Knight was formerly associated with The Preston Laboratories, Butler, Pennsylvania. Now at Minnesota Mining and Manufacturing Company, St. Paul, Minnesota.

trol over the oxidation potentials. Bastress (1947) studied the effect of composition on the reducibility of easily-reduced ions in glass. Manring (1951) and Hopkins and Manring (1953) discuss the effects of redox conditions on the color of amber glasses.

Turnbull and Weyl (1940) discussed the dark stains that form on glass surfaces when the glass is exposed to molten silver salts. The degree of darkening of the glass depends particularly upon the state of oxidation of the ions present. Any area containing an abundance of ions capable of reducing the Ag^+ ions to metallic atoms will attain an especially dark color. Although some pronounced surface cords do produce either light or dark streaks, the glass as a whole has proved to be so sensitive to the silver staining process that complex and confusing patterns of various colors arise. Since these patterns are due largely to composition differences on a scale below that which has any commercial significance, silver staining is of little help in evaluation of cordiness.

A redox investigation was conducted in the Preston Laboratories to determine the effects of a reducing atmosphere (surrounding by pure carbon) and an air atmosphere on amber streaks in commercial ware. Numerous laboratory and commercial glasses were studied, both before and after the addition of various metals, metal sulphides, and refractories. These tests showed that the amber cords followed the generally established concepts of the influence of metal poly-sulphides on glass color under reducing and oxidizing conditions. We also found that contamination of commercial glasses by any of the alumina-silica refractories used in glass furnaces greatly increased the general tendency of such glasses to discolor under reducing conditions. Only optical-quality glasses showed no amber discoloration under severe reduction. It appears, therefore, that redox tests are not suitable for differentiating between different sources of refractory cords, even under the best of experimental conditions.

IK. Interfacial Energies in Molten Glasses

Many papers* have been published which deal with the influence of interfacial energies, surface energies, on the melting of glasses; Gilard (1946) gave an extensive review of methods used to determine the surface tension values. By the term *surface energy* is meant energy per unit surface area, which may be measured in ergs per square centimeter. This is dimensionally equivalent to a force per unit length, which may be expressed in dynes per centimeter and called *surface tension*. The expression surface tension, or its equivalent, surface energy, is commonly used when reference is to a surface separating two material media one of which is gaseous. If the media are liquid or solid, it is usual to speak of their *interfacial tensions*, or *interfacial energies*. In either case, of course, an interface is involved, and the various terms all refer to the same phenomenon. Although these facts are well known, there still has been confusion on these points in some papers.

The magnitude of these surface energies depends upon the nature of the materials in contact. In the melting of glass, there are involved (1) the solid crystalline material of the batch components and the refractories, (2) the liquids formed by their melting, and (3) air and other gases arising from the melting batch and burning fuel. There are thus many interfaces, and the study of their energies is a complex one.

Jebson-Marwedel (1936, 1937a-f, 1942, 1943, 1947, 1948a-b, 1951; with Dinger, 1946) has published the results of particularly extensive and thorough work in this field. He described experiments in which uniform spheres, made of two glasses differing in color and surface tension, were melted in various configurations for various lengths of time in various atmospheres and allowed to cool. The resulting slabs were then ground and polished for study under the microscope. These experiments clearly demonstrated the tendency for a liquid of low surface energy, as measured against air, to spread over the surface of a second liquid of higher surface energy. In his later articles, Jebsen-Marwedel discusses this effect in connection with the melting of batch and cullet, pointing out that in this way glasses of low surface tension tend to spread on the surface of the melt and so present large interfaces for diffusion.

As is well known, the various batch components melt at widely different temperatures. Since the alkali-rich constituents are in the liquid state before material such as sand has softened, much of the melting process consists of alkali attack on the more refractory components, and the spreading of these liquids is an important factor in the melting process. It must be emphasized, of course, that any cord present in a melt is influenced not only by forces arising from differences in interfacial energies but also by those arising from mechanically impressed motions, from density, viscosity, and diffusion differences.

It has been found by Jebsen-Marwedel that the surface energy of glass exposed to a reducing atmosphere is greatly increased, because the glass reacts with sulphur dioxide in the presence of oxygen. Then, in order to maintain the energy of the surface of the melt at a minimum, additional material of low surface energy must rise to the top. Jebsen-Marwedel points out that this phenomenon has an important role in the homogenization of amber and of green glasses fired under strongly reducing conditions.

Since it has been shown both theoretically and experimentally that cords having lower surface tension, with respect to air, than the matrix glass tend to disappear more rapidly than cords which have relatively higher surface tensions, several writers have considered the possibility of adding to glass-tank refractories substances which would reduce the surface tension of any refractory cords that might be formed (Amberg 1946; Badger and Pinnow 1941; Badger, Uhrman and Ottoson 1943). A recent discussion on this is that by Towers (1954). On the other hand, it is held by some technical men that a sufficient increase in the density of the matrix glass would, in itself, prevent refractory cords from accumulating in the tank. The density balance would bring the cords to the top of the melt and then their low surface tensions would cause the cords to spread out upon the surface. Reduction of the wetability of refractories by the glass melt by means of vanadium oxide additions of coatings has been suggested (Lehmann 1955).

*Some of these are: Washburn, Shelton, and Libman (1924); Jaeckel (1932, 1934); Badger, Parmelee and Williams (1937); Parmelee and Lyon (1939); Parmelee and Harman (1937, 1939); Vickers (1938); Endell, Fehling and Kley (1939); Dietzel (1942a, 1942b); Silverman (1942); Knight (1944); Lyle (1945); Weyl (1947); King (1951).

II. Diffusion in Molten Glasses

Although the large-scale mixing that occurs in the process of homogenization of glass melts is influenced by the mechanical forces arising from the charging of batch and the drawing off of finished glass, it is caused primarily by thermal and chemical variations, which in turn affect the physical properties such as surface tension, density, and viscosity. The final complete merging of the various types of glass, nevertheless, must be on an atomic scale, and must take place across various interfaces. Ionic diffusion is also involved in devitrification processes. As has been discussed by Knight (1944), the various glassy phases present in commercial melts are all mutually soluble.* All cords, therefore, tend to mix with adjacent glasses, and will mix completely given sufficient time at high enough temperatures. A cord will not, however, diffuse as a unit into the matrix glass, because of the different diffusion rates of the various ions. The more mobile ions will diffuse more rapidly and over greater distances than the more tightly bound ones.

In 1941, Turnbull studied diffusion in soda-lime-silica-alumina glasses at the Preston Laboratories. Twelve samples involving five compositions were made up. After each sample had been thoroughly homogenized by being melted and powdered several times, it was crushed to 20 to 50 mesh. Portions of these were mixed in pairs to make up six mixtures as shown in Table VII. Mixtures A and B are nominally identical, as are mixtures C, D, and E; mixture F is a third combination. The two component glasses of each pair differed decidedly in composition and in density and other physical properties.

These six mixtures were melted in platinum at 1200° as shown in column 3. Each was cooled rapidly to 500° and then cooled through the annealing range at 2° per minute. Each annealed mixture was then powdered and separated in the centrifuge into several fractions graded according to density. Chemical analyses were made of certain of these fractions from each mixture. On the basis of the weights of the fractions in each mixture, an "average percentage level" was found for each analyzed fraction, with the densest glass being designated as 0 per cent and the least dense as 100 per cent as are the cumulative percentage values in a density-distribution curve. From the analyses and these cumulative percentage values, compositions were interpolated for the 0-10 per cent and the 90-100 percent fractions in each mixture. Typical analytical data and interpolated values (mixture C) are shown in Table VIII.

Turnbull pointed out that several processes were involved in the homogenizing of a pair of such glasses. During the initial stages of the melting, the spreading of the liquids was governed largely by viscosity and surface tension. Since the melts became relatively free of large bubbles after 5 minutes at 1200°, he concluded that in the subsequent homogenization the predominant processes were gravitational mixing and diffusion. There was no way to differentiate between these two later effects.

As one measure of the degree of mixing and diffusion, Turnbull used the ratio ($\Delta F/F$) x 100, where ΔF is the composition difference of each metallic ion in the extreme density fractions, and F is its difference in the two component glasses. This ratio decreases from 100 per cent for no diffusion to 0 per cent for complete mixing. Some of these ratios are shown in column 4 of Table VII. Although he did not believe that the accuracy of these figures was very high, Turnbull considered the sodium and calcium values for mixtures A and C, each melted for 30 minutes, to be in fair agreement, and the same for B & E, melted 12 hours. The alumina values, however, were not consistent. In mixtures D and E the maximum alumina contents occurred in the 10-20 per cent fractions rather than in the most dense, 0-10 per cent,

*In the case of opal glasses, obviously, the solubilities of certain compounds are intentionally exceeded in order to induce the crystallite formation necessary to give the opal appearance.

TABLE VII

DIFFUSION DATA FROM TESTS OF TURNBULL

(1)		(2) Composition of Original Glasses		(3)	(4)	(5)
Mixture				Melting Time	(100·ΔF)	
No.	Oxide	No. 1	No. 2	(Hours)	F	$Kx10^8$
A	Na_2O	12.9	24.6	0.5	16.2	18.5
	CaO	12.0	0.0		25.0	14.7
	Al_2O_3	0.1	0.1		...	...
	SiO_2	75.00	75.3		...	...
B	Na_2O	12.9	24.4	12	2.9	1.41
	CaO	12.3	0.0		7.6	1.05
	Al_2O_3	0.1	0.1		...	...
	SiO_2	74.7	75.5		...	...
C	NaO_2	12.9	24.6	0.5	18.3	14.4
	CaO	12.0	0.0		25.9	14.3
	Al_2O_3	5.1	0.1		59.8	6.81
	SiO_2	70.0	75.3		...	...
D	Na_2O	13.1	24.5	2	7.2	6.5
	CaO	12.0	0.0		17.8	4.4
	Al_2O_3	5.1	0.1		4.0	7.8
	SiO_2	69.8	75.4		...	...
E	Na_2O	12.9	24.2	12	2.7	1.0
	CaO	12.3	0.0		10.2	1.2
	Al_2O_3	5.0	0.1		6.6	...
	SiO_2	69.8	75.7		...	...
F	Na_2O	25.0	25.0	0.5	...	...
	CaO	5.0	0.0		20.0	16.6
	Al_2O_3	0.1	5.1		31.2	12.6
	SiO_2	70.0	70.0		...	...

TABLE VIII

TYPICAL DENSITY SEPARATION DATA FROM DIFFUSION TESTS OF TURNBULL

a) Measured Compositions of Fractions from Melt C

(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Fraction 1 (Most			Fraction 5 (Least	
Oxide	Glass 1	dense)	Fraction 2	Fraction 4	dense)	Glass 2
Na_2O	12.87	17.78	18.13	19.44	20.11	24.60
CaO	11.96	8.03	7.21	5.48	4.52	0.00
Al_2O_3	5.13	4.40	3.53	1.72	0.99	0.11
SiO_2	70.04	69.79	71.13	73.36	74.38	75.29
Weight of Fraction		0.53 gm.	1.76	1.83	0.68	
Average Percentage Level for Fraction		2.6	14.1	84.1	96.6	

b) Interpolated Compositions for Extreme Ten-Per Cent Fractions from Melt C

(1)	(2)	(3)	(4)	(5)	(6)
	Glass	Heavy	Light	Glass	100·ΔF
Oxide	1	10%	10%	2	F
Na_2O	12.87	17.85	20.00	24.60	18.3
CaO	11.96	7.75	4.65	0.00	25.9
Al_2O_3	5.13	4.10	1.10	0.11	59.8
SiO_2	70.04	70.30	74.25	75.29	75.2

TABLE IX

DATA FROM DIFFUSION TESTS OF TURNBULL

Interpolated Compositions of Ten-Percent Fractions from Melt E

(1)	(2)	(3)	(4)	(5)	(6)
Oxide	Glass 1	Fraction 1 (Most dense)	Fraction 2 (Next to 1)	Fraction 5 (Least dense)	Glass 2
Na_2O	12.92	18.65	18.78	18.95	24.23
CaO	12.30	6.67	6.40	5.42	0.00
Al_2O_3	4.97	2.27	2.57	1.95	0.12
SiO_2	69.81	72.41	72.25	73.68	75.65

fractions, as shown in Table IX for mixture E. In fractions 1 and 2 of mixture E, it can be seen that the alumina and silica values are reversed from their usual order.

The second measure of the mixing and diffusion that Turnbull used was a diffusion constant, K, calculated from the $\Delta F/F$ values by use of certain approximations to Fick's law of diffusion. He did not consider the K values to be very accurate. The K values are shown in Table VII where it is seen that the 30-minute values are much larger than the 12-hour values. In this connection, Pask and Parmelee (1943) found that in the diffusion of silver into glass surfaces the diffusion coefficient of Fick's law is constant, at temperatures above the softening point, only for the first part of the adsorption experiment. As time goes on, the coefficient decreases rapidly, which is in general agreement with Turnbull's results.

With increasing diffusing power for an ion, $\Delta F/F$ decreases, whereas K increases in value as the diffusing power of the ion increases. It can be seen that the sodium ions exhibit the greatest mobility, with the calcium ions ranking next. This is in agreement with the results of conductivity measurements and measurements of ion-exchange properties of glasses, in which the high mobility of the alkali ions in all temperature ranges is evident. Further confirmation comes from the work of Thürmer (1933) on the diffusion of BaO in a typical soda-lime-silica melt in an industrial furnace. He found that the BaO diffused more rapidly than did the alumina and silica.

Blau and Johnson (1950) used radiotracer methods to study the application of Eyring's theories of viscosity, plasticity and diffusion to glasses at a series of temperatures. They found a change in atomic mobility in the transformation range of the glass (between $\log \eta = 8$ and 15).

Thus, given sufficient time and high enough temperatures, all cords will mix completely with adjacent glasses, but the various ions will diffuse at different rates and the time required for a cord to disappear will depend upon its composition.

IM. Densities of Molten Glasses

The density of any portion of a glass melt depends both upon its composition and upon its temperature, and the relative densities of various portions will influence their movements in the melt. In the absence of other factors, of course, high density glasses would settle in the melt, while low density glasses would rise to the surface. The relationships between these gravitational forces and the other driving forces which contribute to the flow pattern have not been fully determined.

A number of articles have been published on density measurements of molten glasses.* In general, the densities of commercial soda-lime-silica glasses decrease from about 2.5 gm./cc. at room temperature to about 2.3 gm./cc. at 1300°. Additions of various oxides affect the high-temperature densities of such glasses much as they affect the room-temperature densities. Thus, enrichment in silica reduces the density of molten glass, while enrichment in lime or soda increases it, lime being the more effective of the two.

IN. Flow of Glass in Tank Furnaces

Since all cords must be transported by the molten glass as it flows through the tank and to the forming machines, the nature of the currents in glass tanks is of prime interest in cord research, and much has been published on the subject. The methods that had been used prior to 1936 for studying the flow of glass in commercial tanks were reviewed in detail by Schneekloth and Spiegelvogel (1936). A more recent review by Peyches (1947) was translated by Sutton and Scholes (1948). Hampton (1948) refers to numerous studies going back to 1922. A recent symposium on flow problems was held at the Sixteenth Conference on Glass Problems (Anon. 1956, Bishop 1956).

Clay floats of various shapes and sizes have been used for studying surface currents in hot tanks. These have been projected into the tank at various places and their movements have been observed from at least two positions. The extent of immersion of such a float is an important factor in its behavior. For studying currents at different depths, moreover, submerged floats with tubes extending to above the surface have been used. Glass currents have also been studied by means of a steel plate attached to a vertical rod pivoted on a horizontal arm. The plate was free to swing with the current, and could be suspended at various depths in the molten glass at right angles to the current. The direction and amount of swing indicated the direction and velocity of the current at that depth and location of the plate. A platinum bob on a platinum wire has been used for the same purpose. Immersion thermocouples have been used for determining temperature distribution in the tank. The interpretation of such temperature data is based on the assumption that the surface flow in the tank proceeds from regions of high to regions of lower temperature.

Numerous studies of tank currents have been conducted by means of "tracer" elements added to the batch. Bowmaker and Cauwood (1931), Hampton (1931), and Thürmer (1933) all used BaO to replace lime in typical glasses. The presence of BaO was checked by gravimetric analysis both on the glass issuing from the furnace and on samples taken at various depths in the melt by means of a mold which could be opened and shut in the melt (Thürmer). Bishop (1945) used cerium hydrate as a tracer, introducing it along with the batch. The actual amount of cerium in the glass at any given time and place could be determined by fluorescence or by ultraviolet transmission of samples taken at the machines or

*Jaeger (1917, 1930); Li (1922); Washburn (1922); Sawai, et al (1934); Sawai and Ihoue (1937-41); Endell and Wens (1935); Heidkamp and Endell (1936); Badger and Harmon (1938); Shartsis and Spinner (1951); Shartsis et al (1952, 1953).

from the surface of the glass melt. In this way he accounted for more than 95% of the tracer batch introduced into the furnace. Five years later, he discussed a similar study made after some major alterations in the glass tank studied before (Bishop 1950). Major changes in the appearance, uniformity and amount of cerium at the various machines were found between the old and the new tank design and charging systems. Still later (Bishop 1953) he discussed these results further in the light of Peyches' (1947) work, and compared container and flat-glass tank flows (Bishop 1956). Radioactive tracers have also been used (Cox and Laing 1954; Peyches 1947) to trace flow lines. Woodall (1954) used an under-glass sampler made of fused silica which he recommended as being smaller than metal ones, and as contributing less contamination to the sample and also to the glass in the tank in case it breaks. He used density and thermal expansion measurements to compare the left and right halves of the glass in a tank fed by two screw feeders. Although these feeders drew on the same batch hopper, he found unequal cullet loads and unequal acid-solubles in the fed batch. The differences in the glass melt caused by these variations continued throughout the length of the tank, showing that this tank design was ineffective at causing mixing in the melt.

Somewhat similar to the method of tracer elements is the method of Bishop and Staples (1946) which uses density difference as the indicator. An abrupt batch change is made, which results in a change of density of the glass. The progress of the density change can then be followed through the furnace by means of samples taken at various places and levels in the glass melt by the Thürmer technique. The water-quenched samples from the sampling mold must be given a standard annealing before the relative densities are measured. Bishop and Staples studied a furnace in which the first appearance of tracer material at the machines was very slow compared to other furnaces. They found in this "slow" furnace that the whole melt moved forward as a unit, as shown by nearly identical density-time curves obtained on samples taken at various levels at any one location. In "fast" furnaces, the first tracer material comes through many times as fast as the average throughput; e.g., Hampton (1931) reported speeds up to 10 times as fast.

Schneekloth and Spielvogel (1936), Horak (1945) and Peyches (1947) all discuss the "post mortem" study of shut-down glass tanks. Thus, coloring oxides can be added to the batch before the end of the run. Their distribution in the frozen glass can then be studied along with the distribution of colored products of refractory attack, partially melted glass batch, bubbles, etc. Such evidence, however, must be carefully interpreted, since some rearrangement will take place in the glass as it freezes. For such study, it is best that the tank be frozen without lowering of the glass level. Tank block erosion yields further information. If, for example, small holes are drilled in the refractory blocks as the tank is assembled, the nature of the subsequent erosion at the mouths of these holes will indicate the direction of glass flow past the blocks.

Problems involved in the use of model tanks in the investigation of glass flow have been discussed in detail by Schild (1933, 1934) and by Buckingham (1937). Both authors emphasize the difficulties inherent in the development of adequate models, and in the interpretation of the small-scale results in terms of commercial melting practice. The same problems are treated by Peyches (1947), who also describes the use of simulative models, such as glycerine flowing in glass-walled tanks. Sawai et al (1954) likewise used glycerine in a model tank made of glass plates.

In a comprehensive paper on the flow of glass in tank furnaces, Preston (1936) collected and extended the information available at that time. Making use of extensive analogies, he discussed in detail, largely on theoretical grounds, what might be expected to occur in glass tanks, from the charging of the batch to the drawing off of the finished glass.

SECTION II. FACTORY PRACTICES RELATING TO CORDS

IIA. Statistical Quality Control Using Physical Measurements

IIA1. Statistical Quality Control

It was stated in the Introduction that the answer to the problem of cordy glass is simply the production on a commercial scale of chemically homogeneous glass. In order to insure that the glass remains homogeneous to the required degree, periodic checks are essential. For reasons already mentioned, chemical analysis is impractical as a routine control, so it has been necessary to find physical properties which vary markedly with composition and which can be rapidly and precisely measured. Thirty years ago Payne (1928a, 1928b) pointed out the usefulness of density measurement as a means of glass tank control. Since then, control by density measurements has come into wide usage, particularly since the development of sink-float comparators. Several other physical properties which can be measured readily likewise have been applied to various extents.

To be of greatest value, these periodic measurements must be treated statistically. Starting about 1942, the control-chart method of Shewhart (1931) was applied to this problem. Statistical quality control, "SQC", had been used with considerable success in many industries for a number of years, and the mathematical concepts involved had been discussed by Pearson (1933), Shewhart and Deming (1939), Simon (1941), and the American Standards Association (1941, 1942). Later useful general references on SQC include books by Grant (1946), Brownlee (1949), and Dixon and Massey (1951), and articles in the ASTM (1950d, 1951, 1953c).

Early applications of statistics to ceramic problems include articles by Westman (1927), Ferguson (1930), Flint and Lyle (1932), Dudding and Baker (1933), and Preston (1937). The direct application of SQC to glass plants was first discussed in two anonymous articles (Anon. 1941b, 1943b), and by Preston (1943, 1945). The first extensive paper was by Ghering (1944) who presented actual factory control charts on density. One of his charts is reproduced in the HANDBOOK OF GLASS MANUFACTURE (Knight, 1953b). Purcell (1949) and Stergion (1954) discussed and illustrated the instituting and development of SQC programs in glass plants. Stergion emphasized the use of several control limits on control charts to give warnings of trouble, and to differentiate between subquality ware which should be reinspected and useless ware.

The statistical control chart is valuable in two ways. First, it indicates any unusual variations due to deficiencies in the raw materials, batch processing, or glass melting, which were previously unsuspected by the plant operators. Thus, by close integration of factory practice with the control chart data, operating difficulties can be early detected, identified, and, oftentimes, corrected. The control charts have the second advantage of a very strong psychological influence upon the factory workers. These visible evidences of control or the lack of it greatly increase their interests in good factory operation.

IIA2. Applications of Physical Measurements

Any physical measurement applicable in SQC work must fulfill several requirements: (1) appropriate glass samples must be readily available; (2) the property which is measured must be sufficiently sensitive to the glass composition; (3) the measurements must be simple, rapid, and economic, and (4) the measurements must be sufficiently reproducible. A number of glass properties have been found to fulfill these requirements to varying degrees. Symposia dealing with this work were conducted by the American Ceramic Society on density (Anon. 1946) and by the Society of Glass Technology (Anon. 1948b). Lillie (1954b) gave a thorough review of the role of SQC in glass production and sales, and of the various physical properties utilized in control work, including *viscosity, thermal expansion, density, electrical properties* and *optical properties.*

Relative *density* measurements have been used most for this control work. Extensive applications of density have been discussed by Ghering (1944), Coe (1949), Holene, Johansen and Karstad (1953), and reviewed by Knight (1953b). All used the density comparator technique. They discuss the sampling problems, the statistical handling of the data, and the density variability limits desirable in good factory practice.

Several workers have combined *density* measurements with other routine measurements. Thus, Coe (1949) used control charts on *stress* (birefringence) along with his *density* ones. Bastick and Gould (1949 compared *density* measurements by the Archimedes method with *refractive index* measurements by the comparative method described by Holmes (1945). They based their comparisons of the relative precisions upon: (a) a figure of 0.0007 gm/cc variability in density, derived from one of Ghering's early examples, (b) density and refractive index values calculated from analytical data, and (c) their figure of 0.0001 as the maximum error of measurement by the Holmes technique. As mentioned above, Knight (1953b) subsequently reported laboratory standard deviations in several glass plants to be about 0.0001 gm/cc on his settling method and about 0.0002 gm/cc for Duff's cooling method. He also commented on the wide range of reproducibilities found for the Archimedes method depending upon the skill and experience of the operators. Bastick and Gould found that a variation of 0.0190 in density corresponded to a variation of 0.0037 in refractive index method. On the basis of these data, it is apparent that variability in glass composition can be detected with much greater precision by the comparator methods for density than by the Holmes refractive index method. This is opposed to the conclusion of Bastick and Gould who believed that refractive index was preferable to density for SQC purposes.

Maia (1949) recommended weekly determinations of *density, softening point* and *refractive index* combined with monthly *color tests* and *chemical analyses.* Lehnert (1955) found that *density, refractive index,* and *electrical conductivity* are suitable for rapid, routine control tests, but found *thermal expansion* tests not suitable. Staton and Maycock (1949), however, combined *density* and *thermal expansion* data on specimens annealed in a rapid (45-minute) cycle. They used the differential-to-silica method using an optical lever to measure the expansions between 0 and 400° at rapid rates (4° per minute to 100° plus 12° per minute to 400°). By means of a mathematical correction they converted these data to values equivalent to their standard rate of 2° per minute. For density measurements, they used both the Archimedes method and a sink-float method using four tubes of different density all at 28 ±¼°. As is discussed below, Padmos also found *thermal expansion* a useful control property.

Plumat (1953a) considers that *density* (sink float method) combined with *electrical resistivity* gives adequate glass-composition control. Grekila (1952) used mathematical and statistical analysis of *density* (density comparator) and *softening point* (Poole 1949a) data to control glass production. He discussed simple graphical methods to relate *density* and *viscosity* to composition changes. He used pieces both from ware and from annealed doghouse samples for both tests.

Numerous workers also have reported on procedures not including density. Thus, Manners and Partridge (1949) discuss the use of *refractive index* as a control on batch mixing in a process in which the glass is melted in pots and these are then poured into a tank furnace for continuous manufacture of tubing. As a result of these controlled experiments, the batch house equipment was altered and new handling methods were initiated.

Viscosity measurements, and their related *annealing, strain* and *softening points,* have had much study. Pioneered by the studies of Littleton (1927, 1940), the fiber elongation method has provided definitions of these reference points. Falter (1945) suggested some changes in the methods. The ASTM has tentative methods for testing the *annealing* and *strain points* (1954a) and the *softening point* (1954c). Lillie (1954a) gives recommendations concerning revision of the definitions of the *annealing* and *strain points.*

Lindroth (1945) described an apparatus for measuring simultaneously and simply on a glass rod the *thermal expansion,* the *transformation point,* and the *softening point.* He used an optical lever system to follow the expansion of the rod. After calibration by a known rod, the apparatus can give absolute data. Another instrument utilizing optical recording (Anon. 1947) can be used either for absolute *thermal expansions* or for comparing two samples.

Padmos (1947, 1951) used *stress* (birefringence) measurements on glass-to-glass and glass-to-metal seals as routine measurements of *thermal expansion.* He found these tests to be simple, rapid and suitable to SQC. He points out that the stress buildup in both kinds of seals is related to the solidification temperatures of the glasses as well as to the thermal expansions. Similarly, the

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Pacific Coast Glass Division Meeting— a review of Glass Division Papers

• The Ambassador Hotel on Wilshire Boulevard in Los Angeles was the Convention Headquarters of the Ninth Pacific Coast Regional Meeting of the American Ceramic Society held October 17th to 19th. The attendance was very good in all sections; approximately eighty-five persons attended the Glass Division Meeting. This interest in the meeting was unquestionably due to such factors as the ever-growing glass and ceramic industries in the West, the excellent technical papers, and of course, the lure of Southern California.

The general theme of the convention, "Human Relations", was the subject of an excellent talk by Winthrop Rockefeller. With present technological advancements, human relations and worker psychology take on new importance.

Brigadier General V. R. Haugen, Deputy Commander of Development, Wright Air Development Center, Dayton, Ohio, delivered an outstanding presentation of the importance of ceramics to the nation's jet propulsion program.

The papers of the Glass Session covered a wide range of subjects in the glass field. The quality of the papers was excellent and compensated the out-of-town glass people for the long travel involved.

Chad Dillion, chairman, Glass Division, S. C. Section, introduced the session chairmen for the morning and afternoon sessions; Messrs. R. Gentry, Kerr Glass, and W. Seitz, Glass Containers Corporation, respectively.

The first paper of the morning session was by Ted Vega, Latchford Marble Glass Company, "The Use of the Bausch and Lomb 'Spectronic' 20 in the Determination of the Tri-Stimulus Values in Glass". The inadequacies of the human eye to determine the color of glass containers, particularly of colored bottles of various thicknesses, has long been recognized. The determination of tristimulus values has to designate the color with a specific number. In the past, the determinations were carried out with a rather expensive diffraction grating spectrophotometer, which was as a rule, beyond the budgetary reach of most control laboratories. Mr. Vega, therefore, urged the use of the new B & L "Spectronic" 20 for color determinations. He determined the tristimulus values of a series of glasses with this instrument. The same determinations were then carried out with a spectrophotometer (Beckman Model B). After eliminating experimental errors, it was found that the readings between the two instruments were within ±0.5%. The repeatability of the "Spectronic" 20 on the same samples was within ±0.3%. Mr. Vega stated that glass has to be free of striae and must be perfectly polished; otherwise, large experimental errors will be encountered. He concluded that the instrument allows the determination of tristimulus values and thus offers an economic tool to the control laboratory for color determinations, thereby obviating all the arguments present in the visual color determinations.

William Fabianic, vice president and director of Research, Laclede Christy Company, presented a paper, "Glass Furnace Flux Blocks". The essence of his paper was the result of research carried out to develop a denser and more resistant block for the glass furnace, particularly, the bottom. He elaborated on the physical and chemical requisites for such a block and stressed the importance of the alumina content of the blocks with slides, which showed the influence of this constituent on the resistance. Testing procedures of new blocks were covered. The rotary type furnace allows the best comparison not only between blocks but also for different type glass compositions. It is equally important to produce the experimental blocks under actual plant operation rather than on a small pilot plant basis. Mr. Fabianic felt that research carried out and the test results obtained so far justify large scale installations in glass furnaces. Comments from the audience indicated that the industry should have more confidence in the work of flux block manufacturers.

Mr. Robinson concluded that furnace engineers might well consider aerodynamic principles in furnace designs. He feels that this might add to greater fuel efficiencies and longer furnace life.

Mr. E. E. Humphrey's paper, Corhart Refractories Company, "Glass Tank Performance Through the Years", dealt with the performance of two glass container tanks since they were built originally in 1928 and 1936 respectively. Performance data of the two furnaces were covered by campaign and clearly illustrated the tremendous advances made in furnace refractories, engineering, and operation. The campaigns increased from 315 operating days at the start to 1000 days or more today. Tonnage pulls increased from 11 sq. ft. per ton to 5 sq. ft. per ton, while the total tons of glass melted per square foot melting are increased from 28.5 to an all-high of 186.5. The estimate for the present campaign is well above 225 tons. Mr. Humphrey furnished charts to the audience which graphically illustrated the advances. The charts further showed the changes in refractory applications not only in the furnace proper, but also in the regenerative system, portnecks, etc. Furnace failures were less frequent and changed to different furnace sections. Mr. Humphrey felt that the superior performance of today's furnaces was to a great degree due to the human element responsible for the operation of the furnace. In his thinking, the engineer, the supervisor, and the teaser contribute greatly to the success. He stressed the importance of human relationship and "human engineering". Without that, the best constructed furnace and the finest refractories cannot perform well.

The final paper of the session was delivered by T. J. Mahoney, Silicones Division, Union Carbide and Carbon Corporation. In his paper, "Silicone Antiseize Agents and Analytical Determinations". Mr. Mahoney covered

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Precision Etching of Glass Scales

• Information on a number of improved techniques for producing precise etched glass scales has recently been made available by the *National Bureau of Standards.** Methods for the domestic manufacture of high-precision graduated glass circles and reticules for theodolites were developed by Raymond Davis and Chester I. Pope of the bureau staff at the request of the U. S. Army Engineering Board. The techniques may also be applied to the manufacture of glass scales for optical measuring instruments such as dividing heads, indexing tables, cam-rise gages, and the like.

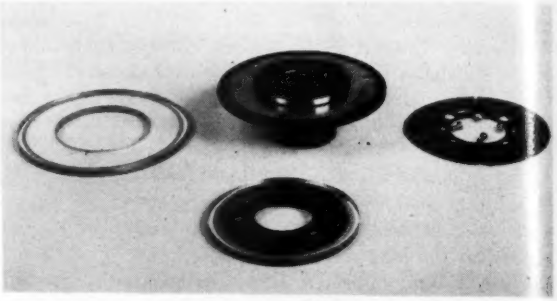
Theodolites equipped with glass scales were not manufactured in this country at the time the Bureau initiated its studies. Although the etching of glass has been widely practiced for a number of years, there was no information generally available for etching the high-precision glass circles required by theodolites. These circles are read by means of a micrometer microscope so constructed that a four-inch circle can be read to one second of angle. A graduation displaced by 0.00001 in (0.25μ) would cause an error of one second in the reading. Thus, the precision required is extremely high and difficult to achieve.

In the course of its investigations, the bureau developed two methods for producing very precisely graduated and numbered glass circles. The steps required by the basic method include coating the glass with a wax resist, engraving, etching, removing the resist, and filling the etched areas. The second technique is a rapid *photographic* procedure designed to produce replicate scales from glass circles produced by the basic method. In the photographic method, the glass circle, coated with a light-sensitive resist, is contact-printed with an optically flat master. The circle is then *developed* by applying a solvent which dissolves out the unexposed portions without attacking the exposed areas. The latter have been rendered insoluble by the action of light. The remaining operations are slightly modified from those of the basic method to compensate for differences in the light-sensitive resist.

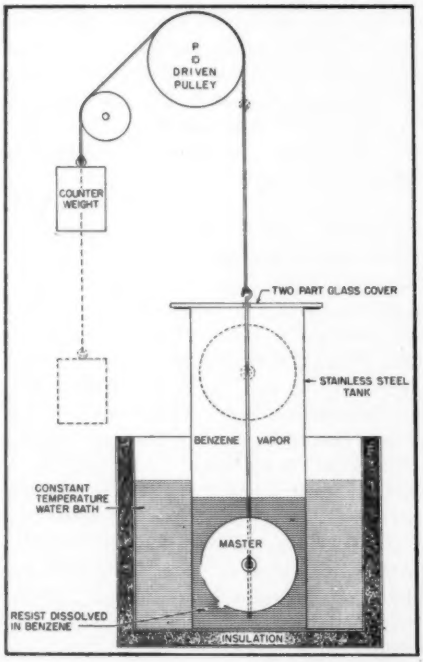
Resists

A considerable portion of the Bureau's study was devoted to the formulation of a number of wax and light-sensitive resists. Although waxes are resistant to hydrofluoric acid, they cannot always be cleanly engraved. The addition of other materials such as rosin, resin, pitch, and asphalt improves the resist's engraving characteristics but may reduce adhesion to glass or resistance to acid. However, several resists were developed which are composed of both natural and synthetic materials and have none of the undesirable properties.

A resist can be applied in either of two ways. In the simpler method, the glass piece is set spinning on a whirler. Then the resist is heated and flowed onto the whirling glass piece. A more uniform coating, free from impurities or lint, is produced by the *pull-out* method, where the circle is submerged in a benzene-resist solution and withdrawn at a constant rate by mechanical means. Other factors affect the quality of a resist: A temperature change of 10 to 20°F. is likely to reduce the bond to the glass, and a resist will not adhere to a glass surface which is not carefully cleaned and dried. Comparisons showed that waterproofing the glass with amino silane not only prevents the resist from lifting during etching but also produces sharper lines.



Theodolite glass circles and mounts studied at the *National Bureau of Standards.* The vertical ring (foreground with clamp ring) and horizontal circle (left) are etched with minute graduated lines and numbers.



Schematic view of apparatus used at NBS for coating glass with wax resists. The glass is immersed in a solution of the wax resist and withdrawn by the pulley at a uniform rate. The speed of the pulley and the temperature and composition of the solution control the thickness of the coating.

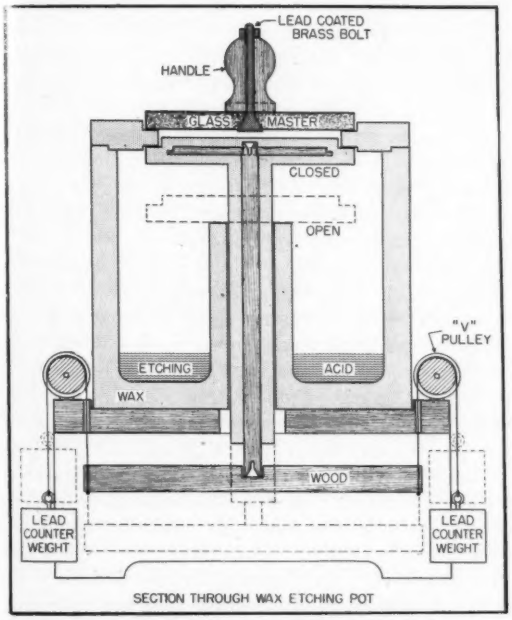
* For further technical details, see Techniques for ruling and etching precise scales in glass and their reproduction by photoetching with a new light-sensitive resist, by R. Davis and C. I. Pope, *NBS Circular 565*, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 30 cents.

Engraving

Two Bureau-designed engraving machines aided the development of the glass etching techniques. One is a reticule-ruling and measuring machine for engraving the glass circles. It was also used to test ruling properties of experimental resist formulations. The other instrument is a pantograph which numbers the graduations. Ruling and scribing tools used with these instruments are made from diamond or steel. The steel tools for engraving graduations are high-carbon steel drill rod hardened by heat-treating.

Etching

After the coating on the glass is engraved, the glass piece is etched by gaseous hydrogen fluoride (either dry or moist) or with an aqueous solution of hydrofluoric acid. Gas etching produces a matte finish and is used principally for etching fine lines that will not be filled with pigment. Etching by gas requires a relatively longer time and is thus more easily controlled. Etching solutions produce a clear etch or a frosted etch, depending on their compositions. Those solutions giving a clear etch generally contain 48 to 60 per cent hydrofluoric acid; those which give a frosted etch contain salts which promote the formation of insoluble compounds on the glass surface. Concentrated hydrofluoric acid solutions are too fast to control when etching fine lines. However, hydrofluoric and phosphoric acid combined produce a mild etching solution which can be controlled for etching very fine graduations.



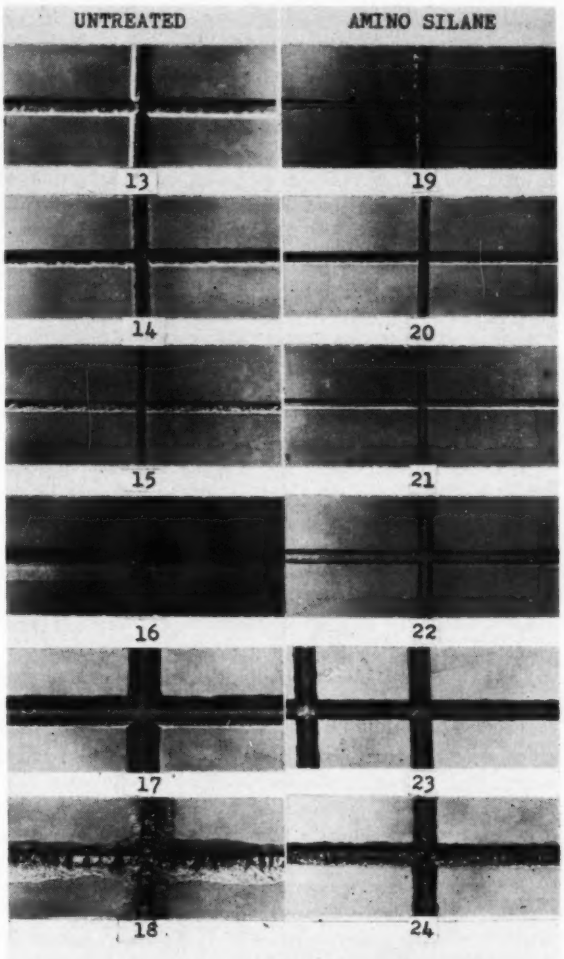
Wax pot for vapor etching of glass master scales at NBS. The glass master is in position at top of the pot and is exposed to the etching vapors by lifting the two counterweights simultaneously. This causes the center unit to be lowered to the position indicated by the dashed lines. Etching with vapors takes from 20 to 60 seconds, thus giving better control than the usual strong hydrofluoric acid, which takes about one second.

Photoetching

The *photographic* method developed by the bureau prepares replicate glass circles from a master circle made by the usual procedure. The photographic method is much faster since no mechanical engraving is required. In this method, a light-sensitive coating is applied to a glass circle which is then contact-printed with the master *negative* and *developed*. The coating consists of phenol-formaldehyde resin with iodoform as a sensitizer. The addition of resorcinol-formaldehyde resin improves the light-sensitive qualities of the coating.

The light-sensitive resin is applied to the glass by the *pull-out* method with special precautions to ensure a very uniform, thin coating. A cabinet of special design was constructed for contact-printing a design on the resin-coated circle from the glass master. After exposure, the unexposed areas are dissolved out by a solution contain-

(*Continued on page* 642)



Photomicrographs showing influence of amino silane on etching solutions studied at the *National Bureau of Standards*. The six pairs of glass pieces have been etched with six different etching solutions. The righthand pieces of each pair were waterproofed with amino silane before coating with resist. Amino silane improves quality of etch for those etching solutions that give good line quality without it.

Summaries of Glass Conference Papers

The Effect of Thermal Currents on Refractories, By Ed Humphrey
Progress in the Use of Silicones in the Glass Industry, By J. Stapp
Problems of Conditioning Glass for Window Glass Manufacture, By H. E. Walker

The Effect of Thermal Currents on Refractories

By Ed Humphrey
Corhart Refractories Company, Louisville, Kentucky

The existence of thermal currents in glass furnaces has long been known in the glass industry; but in spite of this fact, the behavior of the currents in the furnace is not completely understood. Some believe the currents are of great benefit and necessary to good quality glass while others express opinions that a reduction of the currents' intensity results in better glass and longer furnace life by reducing refractory wear. The answer probably lies somewhere between the extreme viewpoints.

I think it naturally follows that improved glass quality will result if contamination from a refractory source is decreased. This opinion is based on observation of several furnaces that had insulation applied to the sidewalls and bottom of the furnace. By insulation I mean flux blocks or firebrick applied to the sidewalls, except at the metal line and fused cast blocks over flux blocks in the bottom of the furnace. After their campaigns, inspections revealed less refractory wear than normally experienced in previous fires. During the campaigns glass quality was excellent. The flow of the convection currents apparently has been slowed by the use of this manner of insulation.

Most operators control the thermal currents to some extent by governing the location of the hot spot in the furnace. This is rather an inadequate way, but seems to be the best and most practical one. The problem is so complex and so many variables affect the currents, that the average operator is satisfied to leave well enough alone. Seemingly insignificant details can have a pronounced reaction in the flow pattern of the currents.

I recall two instances that illustrate this. One operator was suddenly confronted with bad glass from a furnace that had been operating very well. All of the known remedies were tried, to no avail. The source of the trouble was traced to basement windows near the furnace normally kept closed, but opened by an employee for his comfort while working in the basement. The windows were closed and the trouble cleared.

The second case concerned a bottle tank that had a terrific cord. There seemed to be no solution to the problem. Finally, the operator turned off one burner in the fourth port and the trouble cleared. Both operators were of the opinion that these seemingly unimportant actions had influenced the flow patterns of the convection currents and resulted in changed end results.

There is a possibility that more research on the behavior of these currents might indicate a radical departure from present day designs. If so, perhaps the cost would be prohibitive and not practical. Fortunately, there are several avenues that might be explored, with good results, without a great change in present furnaces. A sloping bottom in the melting chamber has been one suggestion. The slope to be from the doghouse to the throat. The original paper stated that experiments had shown that most of the glass moves along the center line of the furnace and at an angle from the doghouse to the throat. The slope of the angle would depend on the type of glass, rate of pull and heat characteristics of the furnace. Such a design would no doubt alter the flow pattern of convention currents as conceived in present day conventional tanks.

Some operators have shallowed their furnaces to reduce the action of these currents. In fact, the trend in the industry has been in that direction. Here again, better refractories have made this possible, for excessive bottom wear has been an obstacle in the past for those who wished to do this. There are those who are at variance with this trend to shallower tanks. They cite the excellent quality and high production from deep flat glass tanks and are firmly convinced that is the way to better glass.

More attention to the nose end of the furnace is in order. Convection currents are very active in this portion of the furnace and have a direct bearing on glass quality and refractory life. Observation of the nose end sidewall will reveal definite evidence of the effect these currents have on refractories. Some operators are reducing the area of the working end and apparently with good results. Hartford Empire unit melters have virtually no refining end. Borosilicate producers long ago found quality improved by minimizing refining area.

The insulation of sidewalls and bottoms has favorable possibilities for most any continuous tank. Present day refractories available to the glass industry make some insulation feasible in many cases. To date, most installations have melted colored glasses, but a few producers are now experimenting on flint furnaces. The result of insulating the sidewalls and bottoms would be a slowing down of the convection currents because the temperature gradient between the top glass and the bottom glass would be less. This would be beneficial in longer refractory life and better quality glass. An incidental bonus would be some fuel saving.

Another recent development in the industry which offers possibilities in the control of these currents, is electric boosting. In all furnaces I have observed which are equipped with electric boosting, glass quality is more easily controlled. This is because heat can be supplied selectively, such as near the bottom of the tank and thus, as in insulating a tank, the temperature gradient is controlled and thereby thermal currents as well. A recent innovation along this line is an application using electrodes in the throat sump only.

Another method that might be used to good advantage in producing good quality glass are air bubbles. I am not prepared to say if the idea is successful when employed in the bottom of the melting chamber. A few companies are experimenting with it.

I want to emphasize that regardless what changes may come in furnace designs or operating practices, as long as we deal with the high temperatures required to melt glasses of various composition, we must recognize the important role these currents of thermal origin play in glass quality and refractory life. Quality of product and cost are always with us and a better understanding of convection currents will contribute to better control of both.

Progress in the Use of Silicones in the Glass Industry

By J. A. Stapp

Union Carbide and Carbon Corporation, Silicones Division, New York, New York

Over the past few years the use of silicones in the glass industry has moved quite rapidly from theory to practice. However, test programs are still under way as there is still room for improvement and much to be learned. To date, experience has shown that the proper use of silicones can provide certain advantages such as: Reduced smoke, soot and oil vapor at the forming area, reduced cost of mold cleaning, reduced danger of flash fires at the forming area, improved appearance of the ware produced, reduced cost of forming lubricant, improved mold release, increased per cent pack.

In the case of delivery equipment lubrication, existing apparatus is well suited for spraying a silicone lubricant on both the shear blades and the delivery equipment. In an actual test comparing paraffin oil with a 220:1 silicone emulsion the cost per day with paraffin oil was $54.57, while with silicone emulsion it was $19.12 per day and the buildup on the shears, scoops, chutes and deflectors was reduced to a new low. In another actual installation, silicone emulsion diluted 66:1 is being used to lubricate the scoops, chutes and deflectors of I. S. machines. No lubricant is applied to the blank molds but they are swabbed occasionally. In this case, the total cost of lubricants is 10 per cent higher, the plant adopted this technique because, in addition to the advantages of silicone release agents mentioned, the swabbing of blank molds has been reduced by about 50 per cent, the consumption of oil adsorbents dropped 90 per cent and carbon spotting on glassware has been eliminated.

The use of silicones to lubricate blank molds requires a considerably more precise spraying technique than do previously used petroleum lubricants. The simple substitution of a silicone emulsion for mold oil in existing spray equipment generally has not been successful. Best results are obtained where a special spray system has been designed to meter the quantity of silicone consistently, and to give uniform coverage to the mold, neck rings and plunger. Since the silicone is non-volatile, it does not vaporize and burn to coat the mold in the same manner as paraffin oil. It, therefore, must be applied in such a manner that the spray reaches all portions of the interior of the mold.

The ability of a silicone emulsion to cool more efficiently than paraffin oil cannot be overstressed. The tendency to use more silicone emulsion must be overcome. Excessive use of the silicone is not only expensive, but also detrimental in that it causes checking of the ware.

Silicone materials presently in use for blank mold lubrication are aqueous emulsions of dymethyl silicone oils with or without graphite added. At present there is no conclusive evidence indicating when graphite is desirable in silicone emulsions. These stock emulsions are diluted with from 50 to 100 parts of water for application to the blank molds. About 0.05 per cent sodium nitrite should be added to the dilute emulsion to prevent corrosion caused by the water. Since silicone is used at such low concentrations, it is easily competitive with other types of mold lubricants.

There also has been some interest in blends of soluble oils with silicone emulsions. One such blend that has been used successfully consists of 5 quarts of silicone emulsion, 4 quarts of soluble oil and 55 gallons of water. In this particular case, the feeling is that the soluble oil imparts an extra measure of lubricity.

We are convinced that much more work is necessary to develop silicones that provide optimum properties for the many variations in glass molding conditions. However, the immediate problem is to determine proper application techniques for whatever silicones are used. After the problems of adapting silicones are resolved, a careful development program can be undertaken to further improve this application by systematically screening various silicones and silicone blends.

Silicone treated bottles are now commercially available. This application promises to expand rapidly as consumers become more aware of the many advantages afforded. Silicones impart a slick, invisible film to the bottles and this treatment greatly reduces bottle scratching, and helps to preserve bottle strengths; thus, resulting in reduced breakage on the filling lines.

Several different silicones are available for this purpose and the application costs are low. The treatment does not delay nor interrupt the production cycle as the dilute aqueous silicone solution is simply applied using a finely atomized fog-type spray while the bottles are in the annealing lehr at a surface temperature of from 250 to 350° F.

Certain silicones will interfere with the adhesion of container labels, while others will not interfere. Also, since some silicone may reach the inside of the container, the silicone used should have the approval of the Food and Drug Administration if it is used for food or beverage containers.

Problems of Conditioning Glass for Window Glass Manufacture

By Henry E. Walker

Harding Glass Company, Fort Smith, Arkansas

To me there are two major problems connected with "conditioning window glass for manufacture"; one is the problem of homogeneity and the other the much related problem of temperature breakdown and heat control.

There is an enemy of glass conditioning that is always present on every hand, ready to spoil one's best laid plans. This enemy can be described in one word *variables*. Set

(*Continued on page* 638)

Inventions and Inventors

Annealing and Tempering

Glass Filaments. Patent No. 2,736,141. Filed May 9, 1952. Issued February 28, 1956. Three pages of drawings; none reproduced. Assigned to A. Silverman by A. Silverman and Leon Parker.

In this invention, reinforcing wires are employed to increase the mechanical strength of the shaped mass, to help the maintenance of the mechanical integrity of the shaped mass, and in passing to the fusion zone.

By employing wires or rods which are readily oxidized, the heat of oxidation of the wires provides a locus of high temperature inside the fusion zone and aids in the obtainment, within the body of the mass, of the temperatures necessary for fusion to produce the desired glass shape. This is a particular advantage in the formation of glass filaments or rods.

The composition of the shaped structure and the wires will depend upon the nature of the glass which is to be formed and upon the composition of the wire and the relative weight of the wire and the complementary glass-forming material used with the wires.

The complementary glass forming material is finely divided and mixed with a binder and formed into a rod shape. The wire is incorporated into the shaped mass in order to form a reinforcing rod within the center of the extruded shape. The rod is then dried and cured and passed to a fusion stage. Fusion may be caused by heat supplied by burners or other heat sources or may result from oxidation of the metallic rod. Examples of the complementary glass forming materials are sodium or potassium silicate and various metal mixes were used such as Al, Mg, or the alloys of various metals.

There were 12 claims and the following references were cited in this patent: Re.22,078, Newman et al., Apr. 2-, 1942; 1,793,529, Taylor, Feb. 24, 1931; 2,171,006, Morgan et al., Aug. 29, 1939; 2,313,296, Lamesch, Mar. 9, 1943; 2,390,354, Clapp, Dec. 4, 1945, and 2,566,252, Tooley et al., Aug. 28, 1951.

Optical Inspection of Glass Sheets. Patent No. 2,735,331. Filed February 15, 1954. Issued February 15, 1954. Issued February 21, 1956. Six pages drawings; none reproduced. Assigned to Libbey-Owens-Ford Glass Company by H. A. McMaster and R. W. Wampler.

This invention relates to an apparatus for automatically inspecting glass sheets for optical defects that are not readily apparent to an unaided eye.

One common defect in glass sheets is lack of parallelism between the surfaces of the sheet. This defect, known as "wedge", may exist uniformly throughout a glass sheet or it may exist only in irregularly located areas of greater or less extent.

A glass sheet to be inspected is positioned in front of a concave mirror and is illuminated by a brilliant concentrated light source located near the center of curvature of the mirror. An image of the light source as focused by the mirror is received upon a small opaque screen of just sufficient area to intercept all of the undeviated rays of light. If there are areas in the glass being inspected that exhibit wedge, these areas (acting as thin prisms refracting the rays of light) produce deviations of the rays of light both when they pass through the glass going to the mirror as well as when they return from the mirror. The deviations so produced are additive and are sufficient so that the deviated rays of light miss the opaque screen and may be collected in a photoelectric cell for signalling the presence of deviated light rays or may be visually detected. As a further refinement of the method, a positive lens is located immediately behind the opaque screen, the lens being of considerably greater area than the screen serves to collect or concentrate the deviated rays of light onto a detecting element or screen.

A positive lens may be arranged to focus an image of the glass being inspected upon a screen; photographic plate or film and such focused image reveals the location of those areas of glass exhibiting wedge because only the light passing through such areas passes the opaque screen and reaches the positive lens.

There were 15 claims and the following references were cited on this patent: 2,231,170, Lindenblad, Feb. 11, 1941; 2,424,976, Golay et al., Aug 5, 1947; 888,6-4, France, Sept. 13, 1943, and Moffit, G. W.: "An Instrument for the Testing of Prisms," *Journal of the Optical Society of America*, vol. 7, pages 831-852, October 19-3, pages 839 and 840 cited.

Feeding and Forming

Forehearth High Efficiency Cooling Section. Patent No. 2,735,229. Filed June 24, 1954. Issued February 21, 1956. 2 pages drawings; none reproduced. Assigned Emhart Manufacturing Company by William T. Honiss.

This invention relates generally to improvements in molten glass feeder forehearths and more particularly to improvements in the cooling section thereof.

A further object of the invention is to provide a novel construction and arrangement of forehearth cooling section roof blocks, so that cooling wind applied to the cooling section scrubs against both the under and upper surfaces of the roof blocks, thus making for efficient cooling. When no cooling wind is being used, fire from burners located at the sides of the forehearth cooling section will pass against both such surfaces of the roof blocks, to increase the firing efficiency of the burners.

Provision is made for practically independent regulations of temperature of the glass in a plurality of successive zones through which a stream of glass flows, in passing through the cooling section of a forehearth of the character described. The result is that one such zone can be used for heating the portion of the glass stream in that zone, to an extent sufficient to prevent any substantial reduction in the temperature of the bottom glass of that portion of the stream, while the succeeding zone can be used for intensive cooling of the top glass of the stream. This treatment thus brings about a condition of substantial uniformity of temperature throughout the cross-section of the glass stream and the proper temperature in the glass at the spout.

The reduction of temperature to be effected may be relatively slight; as for example, when the glass to be fed or otherwise removed is to be at a relatively high temperature, suitable for the production of small charges which are to be manufactured into small articles of glassware. When the charges are relatively large, as for the manufacture of larger articles of glassware, the reduction of temperature is greater and may be as much as 300 to 400 degrees greater than the reduction required for charges for small ware.

There were 15 claims and the following reference was cited in this patent: 2,144,973, Honiss, Jan. 24, 1939.

Bifocal Lens Blanks. Fig. 1. Patent No. 2,734,315. Filed February 11, 1954. Issued February 14, 1956. Two sheets of drawings. Assigned to Pittsburgh Plate Glass Co. by W. W. Poundstone.

This invention pertains to a method for forming a fused bifocal lens.

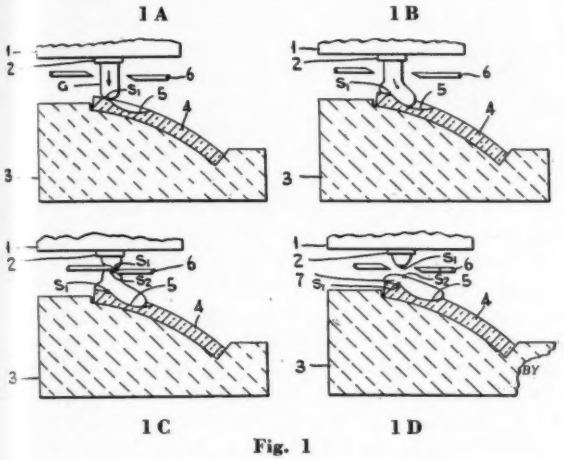


Fig. 1

Referring to Fig. 1A of the drawings, the descending column of molten glass strikes the major element 4 so as to deposit its shear scarred portion of S_1 adjacent that edge of the inclined countersink 5 which is at the highest level. The molten glass flowing downwardly into the countersink moves downwardly into and across the inclined countersink and fuses with the base, without entrapment of air or gasses at the interface. This action is shown in Fig. 1B of the drawings. In Fig. 1C of the drawings, the descending column of glass G has substantially filled the countersink and the shear blades 6 are being advanced to sever the glass. This is done at a time when the volume of glass flowing across the major element is in excess of that required to fill the countersink. Fig. 1D illustrates conditions immediately after the shearing operation. New shear mark S_2 is formed upon the upper surface of the deposited glass to be ground away during the final finishing operation of the lens. Shearing scar S_1 is again formed on the descending glass column. After the glass has been severed, the holder 3 is advanced and a new holder with a new heated major element 4 having a countersink 5 therein is positioned beneath the descending stream of molten glass as before and the operation repeated.

There were 5 claims and the following references cited in this patent: 865,363, Diekmann, Sept. 10, 1907; 869,938, Schwinzer, Nov. 5, 1907; 1,734,428, Haering, Nov. 5, 1929; 1,907,810, Hill, May 9, 1933; 2,145,351, Hazelton, Jan. 31, 1939; 2,223,382, Morehead, Dec. 3, 1940; 2,271,004, Gray, Jan. 27, 1942, and 303,588, Germany, Feb. 7, 1918.

Furnaces

Regenerative System. Fig. 2. Patent No. 2,723,843. Filed October 22, 1951. Issued November 15, 1955. Two sheets of drawings. Harden J. Clark.

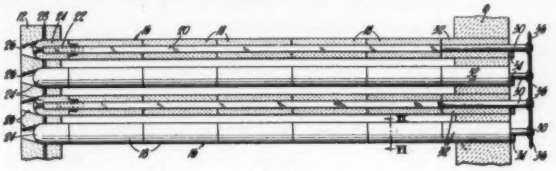


Fig. 2

It is the object of the invention to prevent clogging of the checkerworks in the chamber of a regenerative system by providing staggered tiers of revolving checker tiles. The revolving checkerwork, shown in Fig 2 consists of a plurality of elongated cylindrical refractory tiles or elements 16, which are arranged in staggered horizontal tiers extending between the intermediate wall 12 and the forward wall 6. The revolving checker tiles each consist of a plurality of refractory sleeves 18, assembled on a steel shaft 20. The rear end 22 of each of the steel shafts 20 is encased in a refractory cap 24, which may be pinned to the shaft. The cap 24, is rotatably supported in bearings 26 in the intermediate wall 12. A cast iron saddle plate 28 may be provided in each of the bearings 26, to serve as a reinforced bearing support for the capped end of the revolving tile 16.

One sprocket drive chain is used to rotate two tiers of revolving checker tiles. The checker tiles may be made to revolve in a slow continuous manner during the campaign of the furnace or may be revolved intermittently with the reversal of the furnace as desired. The individually rotated checker tiles may be made to revolve in the same direction or they may be made to revolve alternately in opposite directions, either individually or by rows. Regardless of the direction, the rotation of the individual tiles causes the flue dust, which collects in the checker chamber, to free itself by gravity from the revolving refractory sleeves and fall to the bottom of the checker chamber from where it can be periodically removed during the campaign of the furnace.

There were six claims and eleven references cited in this patent.

Glass Wool and Fiber

Producing Fibers. Patent No. 2,736,070. Filed May 31, 1950. Issued February 28, 1956. Two pages drawings; none reproduced. Assigned Owens-Corning Fiberglas Corp. by Warren W. Drummond.

In connection with fiber forming and collecting processes heretofore employed, it has been a practice to form fibers or filaments into strands and collect them upon a drum.

It has been found that by reason of the tension set up in winding the fibers or strands upon a drum, that the fibers of the individual groups or hanks cohere with

such tenacity that they may be separated only with considerable difficulty involving mechanical picking operations, which further augment the interabrasive action of the individual fibers, with the consequent result that the fibers are greatly weakened.

The present invention provides an apparatus for winding a continuous strand of fibers in a generally circular path around a flexible surfaced conveyor or collector, the surface of which is continuously movable in a direction to convey the collected strand away from the strand collecting zone. The arrangement, including compact fiber forming and strand collecting mechanism, is especially suitable for comparatively high winding speeds with a minimum of tension so that the liability of breakage of the strand is substantially eliminated.

There were six claims and thirteen references cited in this patent.

Preform Machine. Fig. 3. Patent No. 2,725,601. Filed March 4, 1952. Issued Dec. 6, 1955. Two sheets drawings. Ivan G. Brenner.

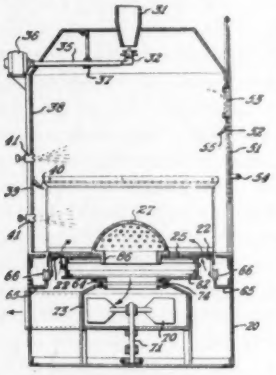


Fig. 3

This invention relates to an improved preform machine of the type in which fibers are caused to be evenly spread about a suitable form and further treated while maintained in uniform position. The machine is particularly adapted to the handling of glass fibers and the like which are properly dispersed about a form and then treated with a hot plastic solution and permitted to cool.

The operation of this machine may be seen from Fig. 3. Suitable form member 27 is fitted within the apertures provided in the top surfaces of the turntable, 25. The table 22 is actuated so as to bring one of these form members and associated turntable within the treating chamber proper. Fibers are discharged into the treating chamber through the nozzle 31, causing them to be widely scattered by the violent action of the distributor 32, as driven by the motor 36.

The amount of air to be drawn along with the fibers may be regulated by adjustment of the flaps 40 and 55. As the fibers are discharged into the chamber and scattered about by the distributor 32, the fan 70 creates a vacuum or suction effect which draws these fibers in even manner about the form 27. Any fibers that may tend to fall clear of the member 27, for example, and thereby tend to cause a jamming between the turntable 25 and the table 22, are pulled clear from the point of juncture of these members by action of the fan in drawing air from the lower base part of the machine as well as from the upper portions of the treating chamber.

A spray of suitable treating solution will then be discharged into the chamber via the various valves 41, as desired. When enough of the fibers and solution have been distributed about the form members, a motor is actuated and the table reciprocated along the track 65, so as to move one of the form members out of the chamber and to bring the other member within the chamber. Then, while the process just described is being repeated, the member first treated may be removed or subjected to further operations as desired. In this manner no waste time occurs.

It should be observed that in connection with the operation of this device the individual turntables are rotated while the fibers are being distributed thereabout.

There were 30 claims and the following references cited in this patent: 2,229,791, Birdsall, Jan. 28, 1941; 2,577,784, Lynam, Dec. 11, 1951; 2,587,814, Borkland, Mar. 4, 1952, and 2,639,759, Simison, May 26, 1953.

Tube and Cane Machines

Sealing Alloy For Soft Glass. Fig. 4. Patent No. 2,730,260. Filed September 26, 1952. Issued January 10, 1956. One page drawings. Assigned to Sylvania Electric Products Inc. by H. M. McCullough.

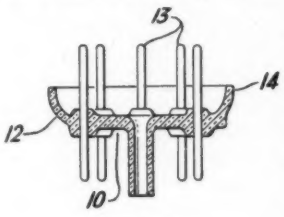


Fig. 4

This invention relates to a glass sealing alloy. More particularly, it relates to an alloy which is capable of being sealed into soft glass bodies in a vacuum type manner.

Sealed through member 10, See Fig. 4, are a plurality of rigid metal rods 13 which extend outwardly to form rigid contact prongs for the radio tube to which the header is sealed. The prongs 13 are preferably formed of the alloy consisting of approximately 42 per cent nickel, 4 to 8 per cent chromium; 1-3 per cent titanium and the balance substantially of iron. Of these constituents, the nickel, chromium and iron give the metal the desired thermal coefficient of expansion and the necessary oxide conditions for sealing the alloy to glass. The titanium content seems to influence the alloy's characteristic in making it more readily oxidizable. This alloy will have a coefficient of thermal expansion between the range of 88 and 98 x 10^{-7} micro. in. per in. between the temperatures of 25-400°C.

Very excellent results have been obtained with alloys which fall within the above range and have been oxidized at temperatures as low as 1400°F. With these alloys it has been possible to make vacuum seals which were 100 per cent good when tested two months after the sealing operation had taken place. The bottom portion of the member 10 is preferably formed of a soft grade glass such as Corning G 12: SiO_2, 63.1 per cent; PbO, 20.2 per cent; Al_2O_3, 0.28 per cent; CaO, 0.94 per cent; Na_2O, 7.6 per cent; K_2O, 5.5 per cent; Mn_2O_3, 0.88 per cent.

There were three claims and the following references were cited in this patent: 2,266,482, Pilling et al., Dec. 16, 1941; 2,284,151, Kingston, May 24, 1942, and 2,292,026, Gillett, Aug. 4, 1942.

Sheet and Plate Glass

Grinding Plate Glass. Patent No. 2,719,390. Filed July 16, 1952. Issued October 4, 1955. One sheet of drawings; none reproduced. Assigned to Pilkington Brothers Limited by Harold G. Jones.

The present invention comprises a disc shaped grinding tool of cast metal alloy for use in surfacing plate glass. The tool is supported in a horizontal plane, and has an axial cavity, a rim and grinding nogs, the surfaces of which nogs are co-planar with the rim. The nogs are disposed between the cavity and rim and are separated by distributing channels for abrasive in suspension flowed from the cavity to the surfaces of the nogs. The metal alloy of the tools has substantially the following composition: 64 per cent to 83 per cent copper, 2 per cent to 12 per cent tin, 0 per cent to 2½ per cent zinc, 5 per cent to 30 per cent lead, and 0 per cent to 1 per cent nickel.

Experiments have shown that a grinding tool having an operating surface cast from a lead bronze alloy containing 20 per cent lead produces excellent results, and similar results have been obtained when the lead bronze alloy is that type known as "gun metal", such type of alloy containing 15 per cent of lead.

The main object of the invention is to produce a smooth grinding surface which is substantially free from pits, and thereby to achieve a great reduction in the amount of work needed for the subsequent polishing process.

There were 15 claims and the following references were cited in this patent: 1,854,508, Drake, Apr. 19, 1932; 1,931,370, Bethel, Oct. 17, 1933; 2,040,054, Lytle, May 5, 1936; 2,460,991, Brasse et al., Feb. 8, 1949; 2,554,070, Stead, May 22, 1951; 2,577,937, Waldron, Dec. 11, 1951, and 2,597,182, Rickner et al., May 20, 1952.

Plaster Applicator. Patent No. 2,736,996. Filed December 19, 1951. Issued March 6, 1956. Four sheets drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Eugene Hoyet.

This invention relates to a method and apparatus for laying a bed of plaster on a horizontal surface. More particularly, the invention relates to a method and apparatus for continuously laying a uniform thin bed of plaster on a succession of moving tables for receiving and holding large sheets of glass during the grinding and polishing operations in the continuous process manufacture of plate glass.

According to the present invention the water and the dry plaster of Paris are handled separately until they are brought into contact with each other on the grinding and polishing tables forming the tops of the cars. The water and the dry plaster of Paris are deposited continuously on the tables as the cars move along the track, successive increments of the moving tables being charged first with a measured amount of water uniformly distributed over the table surface, and then with a measured amount of dry plaster of Paris uniformly distributed over the wetted surface. The plaster bed thus formed on the table surface will be of uniform thickness, and since this thickness ordinarily need be only of the order of about .004 to .007 inch, no stirring or agitation of the mixture on the table surface is required to produce a bed of uniform consistency. Both the water and the dry plaster of Paris are deposited on the table mechanically, thus eliminating the operation of applying the plaster bed manually.

There were 26 claims and the following references were cited in this patent: 354,543, Eberhardt, Dec. 21, 1886; 792,854, Schulte, June 20, 1905; 1,194,520, Lewis, Aug. 15, 1916; 1,589,787, Butter, June 22, 1926; 2,163,687, Jacobsen, June 27, 1939, and 2,212,351, Moran et al., Aug. 20, 1940.

Plaster Applicator. Patent No. 2,736,997. Filed May 11, 1954. Issued March 6, 1956. Five pages of drawings; none reproduced. Assigned to Pittsburgh Plate Glass Company by Ethmer J. Hazen.

According to the present invention the lime water and the dry plaster of Paris are handled separately until they are brought into contact with each other on the grinding and polishing tables forming the tops of the cars. The lime and the dry plaster of Paris are deposited continuously on the tables. As the cars move along the track, successive increments of the moving tables are charged first with a measured amount of lime water uniformly distributed over the table surface, and then with a measured amount of dry plaster of Paris uniformly distributed over the wetted surface. The plaster bed thus formed, on the table surface, is smoothed by passing the plaster slurry covered tables under a curtain of thin flexible sheeting to enhance the uniformity of plaster bed thickness. The provision of the thin flexible curtain improves the uniformity of the thickness of the plaster bed to such an extent that thickness variations of the plaster slurry do not exceed .002". No manual stirring or agitation of the mixture on the table surface is required to produce a bed of uniform consistency. Both the water and the dry plaster of Paris are deposited on the table mechanically, thus eliminating the operation of applying the plaster bed manually.

There were 8 claims and the following references were cited in this patent: 1,031,190, Liebau, July 2, 1912; 1,194,520, Lewis, Aug. 15, 1916; 1,631,203, Hitchcock, June 7, 1927; 2,212,351, Moran, Aug. 20, 1940, and 2,363,631, Walters, Nov. 28, 1944.

Pressing Bent Laminated Glass. Fig. 4. Patent No. 2,714,567. Filed October 17, 1952. Issued August 2, 1955. Two sheets of drawings. Assigned to Pittsburgh Plate Glass Company by Earl Cravener.

This invention relates to apparatus and method for making laminated assemblies of glass and interposed plastic sheets, commonly known as safety glass. More particularly, to the preliminary pressing of curved or bent laminated assemblies and to provide a sufficient seal between the plastic interlayer and the glass sheets in order to dispense with the use of the rubber bag commonly used to enclose the assembled sheets during the autoclaving step.

Preparatory to operating the apparatus, Fig. 4, the valves 25 and 26 are opened. The valve 19 is then manipulated to supply compressed air to the lower ends of the air cylinders, to raise the clamping bar and hold the end of the bag open. An assembly of glass and interposed plastic sheets is pushed into the bag, and back sufficiently from the open end of the bag to permit it to be closed without tipping the assembly relative to the platform, or placing the bag walls under undue stress. Then the valve 19 is turned to supply compressed air to the upper ends of the air cylinders. Thus, the bag will be closed and its upper and lower walls will be

(*Continued on page* 644)

Investigations of Stresses in Glass Bottles Under Internal Hydrostatic Pressure Part III. Electric Strain Gauge and Brittle Coating Studies

The surface stresses in various locations of the three one-way beer bottle designs under consideration (described in Part 1, GLASS INDUSTRY, Research Digest, September, 1956) were calculated from electric strain gauge data on representative bottles (Teague and Blau, *Journal of the American Ceramic Society*, July 1956) in an effort to correlate glass bottle stresses with those determined from photoelastic model studies (Part I) and also with the pressure breaking characteristics of the glass bottles (Part II, GLASS INDUSTRY, Research Digest, October, 1956).

The electric strain gauge method is based on the principle that a change in the length of certain types of electric wire causes a corresponding and proportional change in the electrical resistance of the wire. Thus, oriented filaments of calibrated wire can be closely bonded to a test surface and an applied strain on the surface will produce a corresponding strain in the lengthwise direction of the wire filament, causing a change in electrical resistance which can be measured precisely by the Wheatstone bridge principle.

Prepared and calibrated wire resistance strain gauges are available in many sizes and arrangements, which have been in use for many years in the measurement of surface stresses in materials such as steel, aluminum, wood, plastics, and glass.

In this study, use was made of Baldwin-Southwark wire resistance strain gauges, type A-8. The A-8 is a paper-base bonded-wire strain gauge with helical coil, a gauge length of 1/8in., and a gauge factor of 1.76.

When comparing stress values obtained from strain gauges on glass bottles, with values obtained from studies of photo-elastic models, consideration must be given to the differences in dimension and contour which exist between the model and the glass prototype. The purpose of this comparison is an attempt to correlate the general magnitude and direction of the stresses measured at points of interest on glass bottles under pressure with the results from the photoelastic studies, to account for any differences which may exist, and to establish the validity of the surface stress distribution curves developed from the photoelastic studies. A comparison of photoelastic and strain gauge stress indexes (stress per unit pressure) at various locations in the three bottle designs was given and considering the normal, inherent variability in glass bottles, as compared to the accurately machined photoelastic models, and differences in dimension which are known to exist, the general agreement between the photoelastic and strain gauge measurements was remarkably good in most cases.

For the export-shape bottle the greatest variances from the photoelastic values were in the bottom area and may be readily accounted for by the definite difference in the thickness and contour of the bottom area. Instead of being in the center the high stress point of the outside bottom of these export-shape glass bottles was actually located about 0.7 in. away from the center toward the bearing surface, and the circumferential stress at the bearing surface was also relatively high. This must have been due to the fact that the glass bottles were thinner than the models through the bearing surface and increased in thickness toward the center of the bottom. However, the high longitudinal stress at the inside knuckle of the glass bottle was in excellent agreement with the value determined from the photoelastic model.

For the 12-oz. and quart select-shape bottles, both the outside center bottom and inside knuckle maximum stresses were appreciably below those of the photoelastic models. This can be attributed to the greater bottom thickness and to the smooth inside knuckle contours of these particular lots of bottles. Strain gauge measurements on opposite surfaces at the same point in the side wall of the quart select-shape bottles were in good agreement with values obtained from the photoelastic models. The direction of the maximum principal stress at the various sites measured with strain gauges agreed with that determined from the photoelastic models, with the single exception of the point on the bottom of the export-shape bottle 0.7 in. from the center where photoelastic measurements indicated the circumferential and longitudinal stresses to be approximately equal; the probable cause of this discrepancy was discussed above.

Brittle coatings of various types have been in use for many years as strain indicators for the material underlying the coating. When a brittle coating is made to adhere firmly to the surface of a material and a sufficient strain is applied to the material, a pattern of cracks may be developed in the brittle coating in response to the direction and magnitude of the strains. One of the best known and most widely used brittle coatings today is Stresscoat. Crack patterns developed in this coating indicate the qualitative characteristics of strain, and it is also claimed that quantitative measurement of the maximum strain can be made with a precision of about ± 10 per cent.

In this investigation this coating was used on glass bottles to determine only the qualitative characteristics of the strain produced on their outside surface by internal hydrostatic pressure, and no effort was made to secure quantitative measurements.

On the basis of the experimental results and observations of the several methods employed in these investigations, the following general conclusions seem to be well founded:

(1) The four methods of experimental stress analysis as employed in these investigations have valuable and practical applications to the study of the behavior of glass bottles under internal pressure, and comparative results can be well correlated. Each method has its own peculiarities and special applications which may be used advantageously alone or in conjunction with other

(*Continued on page 636*)

Current Statistical Position of Glass

Employment and Payrolls: Employment in the glass industry during August, 1956 was as follows: *Flat Glass*: A preliminary figure of 31,100 for August indicates an increase of 4.4 per cent from the adjusted 29,800 reported for July, 1956. *Glass and Glassware, Pressed and Blown*: An increase of 5.4 per cent is shown by the preliminary 81,800 figure of August when compared with 77,600 of July. *Glass Products Made of Purchased Glass*: The preliminary 14,700 indicates an increase of 5.0 per cent from the previous month's 14,000.

Payrolls in the glass industry during August, 1956 were as follows: *Flat Glass*: An increase of 2.7 per cent is shown in the preliminary $14,864,867 when compared with July's adjusted $14,470,582. *Glass and Glassware, Pressed and Blown*: An increase of 3.3 per cent is shown in the preliminary $28,070,488 reported for August when compared with the previous month's adjusted $27,166,984. *Glass Products Made of Purchased Glass*: A preliminary figure of $4,374,867 was reported for August. This is an increase of 7.3 per cent compared with the adjusted figure of $4,076,800 of the previous month.

GLASS CONTAINER SHIPMENTS

(All Figures in Gross)

Narrow Neck Containers

	Sept. 1956
Food	1,890,000
Medicinal and Health Supplies	1,152,000
Chemical, Household and Industrial	724,000
Toiletries and Cosmetics	715,000
Beverage, Returnable	317,000
Beverage, Non-returnable	78,000
Beer, Returnable	102,000
Beer, Non-returnable	502,000
Liquor	821,000
Wine	351,000
Sub-total (Narrow)	6,652,000

Wide Mouth Containers

Food	*2,822,000
Medicinal and Health Supplies	330,000
Chemical, Household and Industrial	110,000
Toiletries and Cosmetics	112,000
Packer's Tumblers	71,000
Dairy Products	234,000
Sub-total (Wide)	3,679,000
Total Domestic	10,331,000
Export Shipments	189,000
TOTAL SHIPMENTS	10,520,000

*This figure includes Fruit Jars and Jelly Glasses.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All Figures in Gross)

		Production Sept., 1956	Stocks Sept., 1956
Foods: Medicinal and Health Supplies; Chemicals, Household and Industrial: Toiletries and Cosmetics	Narrow Neck	4,175,000	4,880,000
	Wide Mouth	*3,427,000	*4,106,000
Dairy Products		244,000	281,000
Beverages, Returnable		339,000	1,321,000
Beverages, Non-returnable		59,000	201,000
Beer, Returnable		86,000	271,000
Beer, Non-returnable		509,000	569,000
Liquors		852,000	928,000
Packer's Tumblers		51,000	138,000
Wines		290,000	467,000
TOTAL		10,032,000	13,162,000

*This figure includes Fruit Jars and Jelly Glasses.

Glass Container production, based on figures released by the Bureau of Census, was 10,032,000 gross during September, 1956. This represents a decrease of 24 per cent from the previous month's production of 13,290,000 gross. During September, 1955, glass container production was 11,539,000 gross or 10.5 per cent over the September, 1956 figure. At the end of the first nine months of 1956, glass container manufacturers have produced a total of 107,004,000 gross. This is 3.5 per cent over the 103,365,000 gross produced during the corresponding 1955 period.

Shipments of glass containers during September decreased 34 per cent to drop to 10,520,000 gross. This is a decrease from August, 1956 shipments which were 15,998,000 gross. Shipments during September, 1955 were 11,539,000 gross or 8.9 per cent over September, 1956. At the end of the first nine months of 1956, shipments have reached a total of 105,594,000 gross, which is 3.4 per cent over the 102,098,000 gross shipped during the corresponding period last year.

Stocks on hand at the end of September, 1956 were 13,162,000 gross. This is 3.8 per cent below the 13,685,000 gross on hand at the end of August, 1956 and 1 per cent higher than the 13,040,000 gross on hand at the end of September, 1955.

Automatic tumbler production during August, 1956 was 4,922,000 dozen. This is a gain of 10.1 per cent against the July, 1956 production, which was 4,437,458 dozen.

Shipments during August, 1956 dropped to reach 5,524,000 dozen. This is 1.8 per cent lower than the 5,627,000 dozen shipped during August, 1955. At the end of the twelve months period ending August 31, 1956, shipments have reached a total of 60,212,000 dozen, which is a 2.9 per cent decrease from the 61,995,000 dozen shipped last year.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware during August, 1956 reached 3,130,000 dozen. At the end of the twelve month period ending August 31, 1956, manufacturers had sold a total of 35,511,000 dozen, which was 6.4 per cent lower than the 37,932,000 dozen sold during the corresponding 1955 period.

New Equipment and Supplies

NEW SHUTOFF AND ALARM FOR HEATING PROCESSES

Damol Corporation, 541 Land Title Building, Philadelphia 10, Pa. has introduced a safety shutoff and alarm for automatically controlled processes. It requires no sensing elements or electronic circuitry.

Designated as the Damol Impulse Monitor, the device provides a complete, safe shutdown of the process and sounds an alarm in the event of controller failure in the "on" period; and an alarm in the event of abnormal "off" period or fusing of the power contactor.

The monitor is easily installed and maintenance is negligible. The device operates independently of furnace temperatures.

Although the present models are designed primarily for heat treating furnaces, the principle of the Damol Impulse Monitor can be applied to any process involving heat, pressure or flow where the control system uses an on-off, two position or pulsing type of control mode and where the input is of reasonably uniform duration. Further information and description of the impulse monitor may be had by writing for catalog 256 from the company.

NEWLY DESIGNED FLO-SCOPE

Selas Corporation of America, Dresher, Pennsylvania have announced a newly designed flo-scope for measuring flow rates of air and gases.

Known as the Series F, the instrument incorporates design changes which reduce installation costs by permitting one-man panel mounting; reduce maintenance costs by simplifying cleaning procedures. The flo-scope can handle capacities up to 75,000 cubic feet per hour of air. Continued accuracy is assured because the only moving part is not subject to wear. The flo-scope is individually calibrated at customer's specified flow conditions. The instruments measure flow rates of air and gases, separately or in mixtures, for combustion in furnaces and ovens. They are also employed in measuring, components entering special atmosphere-generating units, in production of industrial chemicals, etc.

NON-CONTACT INDUSTRIAL GAUGES

Industrial Gauges, West Englewood, New Jersey, recently announced the XactRay Gauge. This gauge is a non-contact type, employing an X-ray beam whose energy is transmitted through the material being measured. This makes possible the measuring and controlling of the thickness of plate glass without touching the glass in process, insuring quantity control within one per cent of predetermined standards. The energy is collected by a receiving unit and converted into electrical impulses which in turn actuate the electronic equipment in a main console. From the main console equipment, it is possible to actuate a large scale zero centered meter, a continuous chart recorder or an electromechanical device for actuating sheet rollers, etc., to automatically control the thickness of the material being processed. The gauges operate over wide sheets of material when installed on traversing carriages. Scanning thus can be done manually or automatically and continuously without interfering with processing.

NEW CYLINDER BRUSH GLASS WASHER

Henry G. Lange Machine Works, Inc., 166 N. May Street, Chicago 7, Illinois, have developed a new cylinder glass washer, called the Model 54LW, for washing glass any width from 24 inches to 36 inches. It leaves the glass perfect and completely dry after wash. This new model is available in one side or two side washers, four- or six-brush models. The exhaust is under the washer, making it very compact. Brushes are highest quality obtainable —100 per cent pure dupont nylon tufted and wire bound in aluminum cores; rollers are covered with Neoprene, wrapped to $\frac{3}{8}$ inch or $\frac{1}{2}$ inch thickness then vulcanized to core; completely ball bearing; heavy duty blower for thorough drying; brass adjusting screws and nuts with stainless steel springs on all pressure washers; frame is heavy, rigid, welded construction; motors and blowers are governed by length of brushes. Further details may be had by writing the manufacturer.

CATALOGS RECEIVED

Bethlehem Apparatus Company, Inc., Front and Depot Streets, Hellertown, Pennsylvania, have published a manual titled "Glass Blowing on the Glass Lathe—A Manual of Basic Techniques." The manual describes ten projects and takes the reader through several basic projects, steps leading to increased skill and greater understanding of the possibilities of plastic glass. It shows how to complete each project by a simple method, which when followed, will produce satisfactory results. The project headings are divided into topics such as closing end of tubing, fusing two tubes of the same diameter, fusing tubings of different diameters, making bulbs on tubing, making a "T", etc.

Foote Mineral Company, 18 W. Chelten Avenue, Philadelphia 44, Pa., have published a 38-page folder in loose leaf form, to provide for insertion of new data as it becomes available, containing pertinent data on the chemical and physical properties of lithium compounds. The reliable published information on 16 compounds of lithim has been compiled and is augmented by much new data now being developed by the company's research department.

Harbison-Walker Refractories Company, Farmers Bank Building, Pittsburgh 22, Pa., have just published a most attractive brochure entitled "Better Refractories Through Quality Control". It describes the most comprehensive and effective quality control program of the company and how it insures dependable uniformity of their refractory products.

Minneapolis-Honeywell Regulator Company, Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa., have issued a condensed catalog and price list B43-1. It introduces new ElectroniK Special Class 14 Line of Strip Chart, Circular Chart and Circular Scale instruments. This latest edition of catalog is devoted to instrumentation for metal processing application, also includes specifications and prices of vane-type millivoltmeter controllers, thermocouples, Radiomatic radiation detectors, remote bulb thermometer controllers, flame failure safeguards, limit controls, electric and pneumatic valves.

Arthur D. Little, Inc., Mechanical Engineering Division, 30 Memorial Drive, Cambridge 42, Massachusetts have issued a folder which is useful for quick reference of engineering data on titanium.

"Facts About Titanium" contains a list of the commonly available titanium alloys and their compositions, forming and welding methods, heat treatment and machining information, as well as current and projected prices and other pertinent data.

Looking through chemicals

An amazing 73 billion glass-packed units were sold in this country in 1954 . . . an average of 454 units for each man, woman and child. And today, glass container plants are operating at even greater capacity. Small wonder that demand for soda ash, nitrate of soda, and other glass-making chemicals is at an all-time high.

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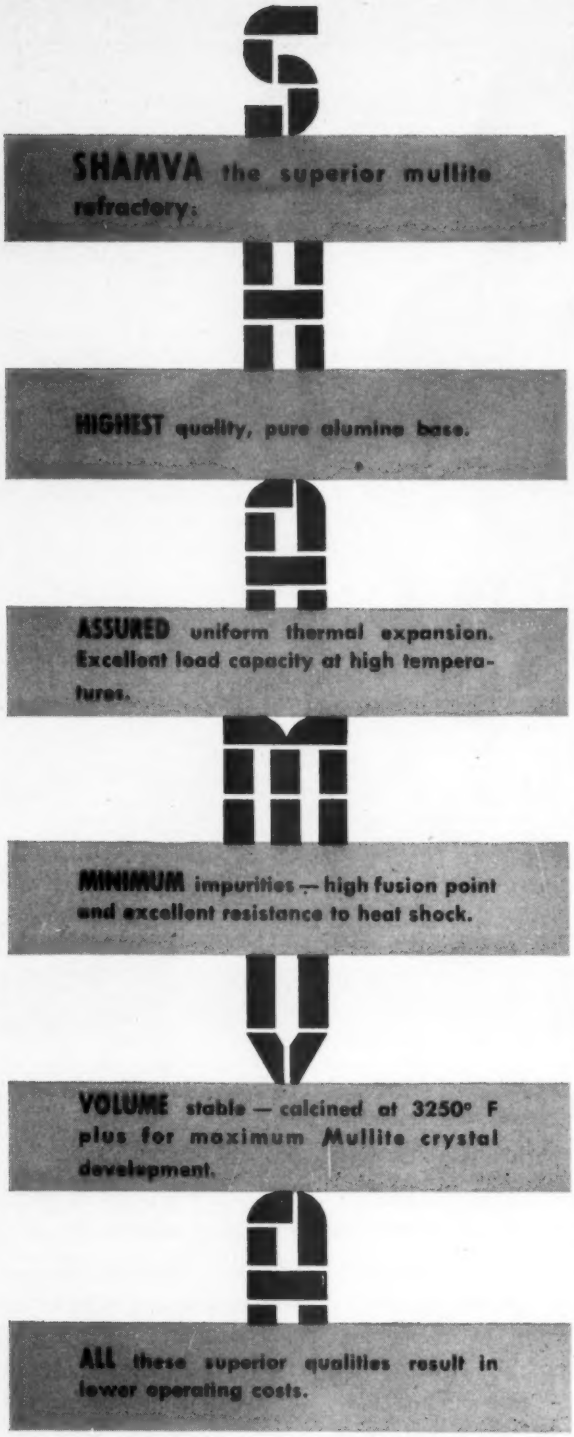
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Pacific Coast Regional Meeting . . .
(*Continued from page* 619)

the methods developed by his company to analyze for residual silicones within the glass container. The use of antiseize agents to prevent surface damage of glass continers is now well established, and is extended to containers for food and drug use. Union Carbide has long realized that applications on such containers require determinations of the amount of silicone left within the treated container. This led to the investigation and development of analytical procedures. He outlined the two methods developed, (A) Cobalt Method, (B) Infrared Method. Mr. Mahoney stated that the Cobalt Method, even though indirect, is well suited for plant control. Octasol cobalt is added to the spray solution to give a concentration of cobalt equal to 1% of the silicone concentration. The analytical procedure is to leach the inside surface of the container with HF., evaporate the solution and change the metallic ions to perchlorates, dissolve with water, and buffer to a pH. of 7.5 8.5, using sodium citrate. Extract cobalt with dithizone reagent. Follow standard procedure for colorimetric determination of cobalt using nitroso R-salt to form colored complex. Since cobalt is contained in the glass, blank runs are required. The Infra-red Method is a direct method, analysing for the silicone itself. The treated bottle is rinsed with benzene. The solution is evaporated with powdered KBR. This deposits on the KBR crystals from which a wafer is prepared. The silicone is determined by the infra-red procedure. Mr. Mahoney considered this method superior, however, felt that the amount of work required, and the expensive equipment limited the method to large laboratories. He concluded that both methods are very satisfactory and that he has found that analysis of a variety of containers treated with Union Carbide silicone indicate that they usually contain less than 0.5 p.p.m. of silicone.

"The Upward Trend of Glass Containers" was the title of a paper presented by Frank Wright, West Coast Manager, Glass Container Manufacturing Institute. Mr. Wright presented a brilliant picture of the growth of the glass continers industry in California. His talk was supported by a most interesting and factual presentation of statistical data relative to the growth of California and glass container production. Glass containers in various products fields were analyzed and discussed as well as competitive container trends. It was pleasing to note that 99% of all soft drinks are packed in glass. Mr. Wright's analytical projections of the figure growth of the industry are most promising as well as the promotion campaigns of the industry to further stimulate the use of glass containers on the West Coast.

Dueward Lynch, sales engineer of The Overmyer Mold Company's, South Gate, California plant concluded the morning session with his paper, "Flame Hardening". He first listed the requirements of satisfactory mold iron, shock resistance, heat resistance, no scaling, and the ability to hold dimensions. Present methods to improve mold iron are alloying and heat treatment. Alloying changes the internal structure of the iron and makes it more suitable for heat treatment. Mr. Lynch discussed various methods to harden the mold iron. The induction method produces a satisfactory mold iron, however, is too costly for universal use. Oven treatment was not

found satisfactory as in many cases, the iron cracked and broke. Flame hardening is perhaps the most satisfactory process today. It consists of exposing the iron to a series of torches and subsequent quenching in water or oil. Of special interest, were his comments on the Toci-Process, for surface alloying of metals particularly, low carbon iron. This new process permits the transformation of the surface of metal articles into numerous alloys of the metal. This is carried out in hermetically sealed ovens by diffusion in the gaseous phase. This diffusion results in the exchange of up to 50% of the atoms of the metal surface of the article to a depth of 250 microns by the metals forming the alloy. In the case of molds, the most important advantage is that the molds are first machined and then treated by the Toci method, which will not affect the dimensions.

Two sets of molds are being tested at this time in Vienna; one set of omiron and one set of omnod iron. As soon as the tests are completed, the results will be made available to the industry.

The afternoon session was opened with a paper by R. C. Abbey of General Refractories Corporation, "Refractory Applications in High Temperature Furnaces". Although Mr. Abbey treated furnaces in general, his comments were primarily on the use of basic brick in glass furnace regenerator chambers, and checkers. He illustrated his talk with slides showing typical installations. Mr. Abbey discussed in detail the reactions of batch carry-over with basic brick, chemical changes within the brick, and reactions with adjacent refractories. A series of slides illustrated typical strains and spalls. Mention was made of the internal use of steel in basic brick which stops spalling and increases the life of the installation. He stressed the importance of compatible materials in a furnace. Of special interest was a color film taken by Mr. Abbey in South America of copper, steel, and other furnaces and industrial installations.

"Visual Device for the Study of Flow Characteristics of Gases in Regenerative Furnaces" was the title of the paper by P. W. Robinson of Latchford Marble Glass Company. Mr. Robinson constructed a model of an end port furnace in the Latchford Marble plant. The model was equipped with a suitable suction device and inlet for colored smoke. Velocities of the colored smoke or air could be changed at will. The model further permitted the photographing of the air stream, both vertically and horizontally; however, flattened the gas stream vertically.

R. W. KAZMAIER PROMOTED

Richard W. Kazmaier, who started his career with Libbey-Owens-Ford Glass Company in 1929 as assistant office manager at the East Toledo plate glass plant, has been promoted to superintendent of the Laminating plant it was announced by C. W. Davis, executive vice president production, and H. M. Dodge, plant manager.

He succeeds Albert W. Kleine recently promoted to production manager of the combined East Toledo plants.

Mr. Kazmaier became office manager of the wartime Plexiglas plant at Rossford in 1942 but returned to East Toledo five years later as office manager of the Laminating plant. In 1950 he became assistant superintendent of the Laminating plant.

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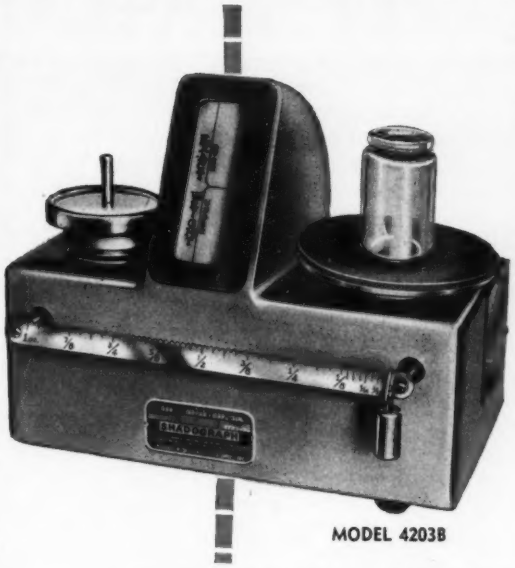

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Cords in Glass . . .

(*Continued from page* 618)

geometry of the seals is important. If reproducible test conditions are maintained, this is a much faster and more useful technique than the usual standard methods (ASTM 1954b).

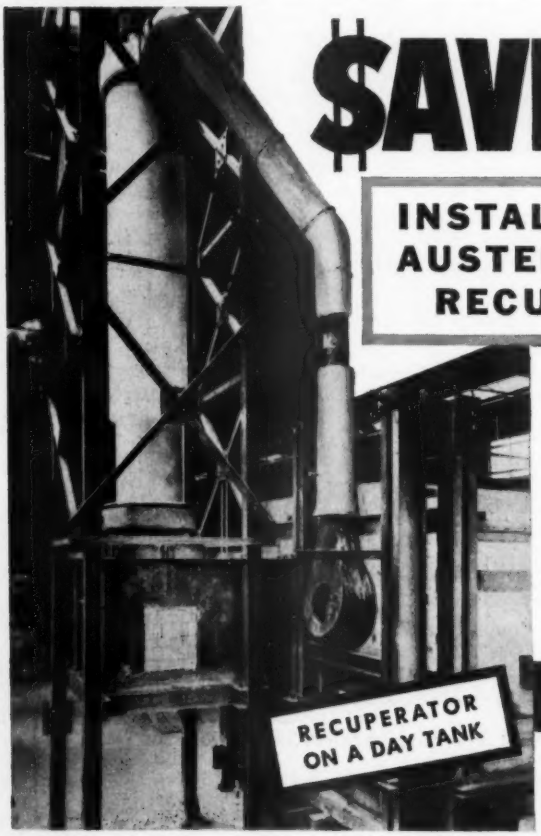
Poole (1949a) described a useful furnace and technique for obtaining *viscosity* data in the annealing range. He reports values precise to within ± 1 per cent in the range of 10^7 to 10^{15} poise. With this procedure, he carried out thorough viscosity studies on alkali-alkaline earth-alumina-silica glasses (Poole and Gensamer 1949) and on alki-silicate glasses (Poole 1949b). He likewise discussed the application of this equipment and viscosity information to routine SQC on container glass (Poole 1949c). He discussed the determination, by means of special graph paper, of the viscosity-temperature curve from the measurement of the viscosities at only two temperatures about 20° apart. From this curve, he then calculated, using a special slide rule, the *annealing, strain* and *softening points.* After receipt of the fiber samples, which were drawn directly from the glass melt, only 10 minutes were needed to complete the measurements and the calculations. Poole found that these calculated reference points agreed with directly measured values to within less than 5 per cent, and usually within 1 per cent, for glass compositions such as were reported by Robinson and Peterson (1944) in their report on container glass viscosities. On any given glass, he reported reproducibility to within ± 0.3°. Thus the method is very reproducible and rapid, and is ideally suited to SQC.

The effect of glass composition upon its *electrical conductivity* has been studied by Seddon, Tippett and Turner (1932), Littleton and Wetmore (1936), and Badger and White (1940), in addition to Plumat (1953) and Lehnert (1955) mentioned above.

L-O-F GLASS & PITTSBURGH PLATE CONCLUDE NEGOTIATIONS FOR SECURITY BENEFIT PLAN

The United Glass and Ceramic Workers of North America, AFL-CIO-CLC and Libbey-Owens-Ford Glass Company and Pittsburgh Plate Glass Company have concluded the negotiations provided for by their three-year agreement entered into September 25, 1955. Under the terms of that agreement, the parties could elect as of September 25, 1956, to place five cents per hour into the Security Benefit Plan or alternately into other employee benefits or wages. Under this provision the parties elected to increase contributions to the Security Benefit Plan by five cents per hour in lieu of a wage increase or other employee benefits.

These unique Security Benefit Plans, covering 23 000 employees of the two companies, and providing for the creation of a trust account for each employee were established by agreement in September, 1955. These plans provide for payment in the event of unemployment due to layoffs or extended illness. In addition each employee has a vested right to the balance in his security fund if his employment is terminated for any reason or upon his retirement or death.



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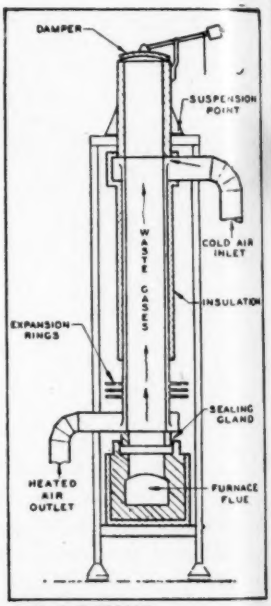

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Research Digest . . .

(*Continued from page* 628)

methods. The method selected for a given investigation depends on the objectives, on costs, and on the time available.

(a) Three-dimensional photoelasticity is useful in making detailed studies of the stress distribution on carefully prepared "frozen" models. This method is expensive and somewhat tedious, but it is valuable for initial studies to establish the over-all characteristics of a stress system. Its use is limited to static stress systems, but this method seems to yield the most extensive and satisfactory information.

(b) Bottle breakage methods reveal the strength and fracture characteristics of actual glass bottles under static or dynamic stress systems. Grit-blasting, to give a uniform surface condition, causes such bottles to break in the location of maximum tensile stress. The use of this technique facilitates the study of bottle design and the determination of the relative strength of various parts of a bottle.

(c) The electric strain gauge method finds practical use in measuring the surface strains, at specific locations on glass bottles, when the general stress system is known. Reliable measurements can be made in relatively small areas under static or dynamic stress.

(d) The brittle coating method finds application primarily in qualitative surface strain studies of glass bottles under static or dynamic loading, particularly the location and orientation of the maximum principal strain. This method is also quite useful in preliminary studies to aid in selecting the appropriate location and orientation for electric strain gauges.

(2) The surface stress distribution curves developed in this investigation from photoelastic measurements are valid representations of the state of stress on the surfaces of glass bottles under internal pressure. Although these curves apply particularly to the one-way beer bottle designs studied, they should also be applicable to other bottles of similar dimension and design. They should be useful in designing bottles with good pressure strength characteristics and also in the explanation and diagnosis of glass bottle fractures due to internal pressure.

(3) Although the highest tensile stresses developed by internal pressure in a bottle tend to occur at the inside juncture of the heel and bottom, these tensile stresses cover a relatively small area and the surface is generally pristine and well protected from normal abuse. Experience has shown that the high strength of this interior surface is usually retained in use, particularly in one-way bottles, and therefore, pressure breakage should rarely, if ever, originate at the inside knuckle.

(4) Reducing the bottom thickness of a bottle appreciably increases the tensile stresses developed by internal pressure at the inside knuckle and outside bottom surface. This effect may be overcome to some extent by tapering, or toeing-in, the heel sufficiently to give an adequate decrease in the effective bottom diameter, and by maintaining large radii in turning the heel and bearing surface contours.

(5) Smooth, gentle contours in the transition area between the side wall and neck of a glass bottle are generally desirable to prevent excessive discontinuity stresses. Sharp, concave radii should be particularly avoided, although many neck and shoulder designs such as the export shape do not cause serious stress concentrations.

(6) The consistent characteristics of the fracture of glass bottles by internal pressure can be explained in terms of the maximum principal surface stress distributions as determined by experimental stress analyses.

(7) The location of the origin of fracture produced in glass bottles by internal pressure depends on the condition of the surface and on the magnitude of the stresses. Bottles with pristine surfaces tend to break at rather random locations, depending primarily on the location of microscopic surface discontinuties or extremely small surface flaws or bruises caused by inadvertent contacts on the surface. Bottles with surface contact abuse, caused in handling, tend to break in the abuse according to its severity and to the magnitude of the stress in the region of the abuse. Bottles with uniformly conditioned surfaces (such as grit-blasted bottles) tend to break under internal pressure in the region of the highest tensile stress in the conditioned surfaces.

• Lloyd W. Smith, who joined the engineering staff of Libbey-Owens-Ford Glass Company in 1950, has been promoted to assistant plant engineer of the Ottawa Ill., plant it was announced by Roy A. Nyquist, director of engineering.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, AND CIRCULATION REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, AS AMENDED BY THE ACTS OF MARCH 3, 1933, AND JULY 2, 1946 (Title 39, United States Code, Section 233)

Of THE GLASS INDUSTRY, published monthly at New York, New York, October 1, 1956.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Cyril B. Delgado, 55 West 42nd Street, New York 36, N. Y.; Editor, Cyril B. Delgado, 55 West 42nd Street, New York 36, N. Y.; Managing Editor, None; Business Manager, None.

2. The owner is: Ogden Publishing Company, 55 West 42nd Street, New York 36, N. Y.; John T. Ogden, 55 West 42nd Street, New York 36, N. Y.; Katherine Waller Ogden, 55 West 42nd Street, New York 36, N. Y.

3. The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other security are: None.

4. Paragraphs 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than of a bona fide owner.

(Signed)
CYRIL B. DELGADO, *Publisher.*

Sworn to and subscribed before me this 15th day of October, 1956.

David M. Cohen
Notary Public in the State of New York
No. 24-5736200
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Summaries of Glass Conference Papers . . .

(*Continued from page* 623)

your conditioning pattern and achieve the highest degree of efficiency possible and "variables" will still remain a constant threat.

What are some of the "variables"? This may be answered in part by saying "any variation from a stabilized, set, or uniform condition being used to produce the desired conditioning of glass". Needless to say, this set of uniform conditions will not necessarily be exactly the same on any two furnaces although similar results may be achieved on all the furnaces so ideally set.

What are some of the variables? First, the hot spot from each individual pan of port burners. Does the hot spot remain in the same place relative to the furnace on each reversal? Or do they vary from the centerline? Can this variable be controlled? Second, how is the hot spot in the furnace determined; does it remain in one place unless purposely moved? Is there more than one hot spot in the furnace? Does the location of the hot spot affect the glass conditioning? Third, does the type fire on a furnace affect conditioning? Oxydizing vs. reducing on first port, or vice versa?

There are many devices used in temperature breakdown; among them are: The sprung "shadow arch", the suspended "shadow wall", floater skimmers, hairpin coolers, straight pipe coolers, cold air, venting, insulating, electric heat applications.

What happens to the glass that causes one operator to remove a suspended shadow wall and install a sprung arch and another operator to remove the sprung arch and install a suspended shadow wall after having experience with both kinds? What is the primary function of a shadow wall? How does a shadow wall or arch affect glass conditioning?

What was the original purpose for using floaters used for the same purpose today as they were originally? What happens in the tank when floaters are used? What effect do they have on glass conditions?

In using hairpin coolers for temperature breakdown, how do they affect glass condition? Do they affect convection currents?

How does the use of straight pipe coolers affect conditioning? Is it different from hairpin coolers?

Where cold air is introduced as a cooling agent, how does it affect conditioning and firing of the furnace?

What effect will venting in the refining area have on conditioning of glass?

To what extent will the above devices affect surface tension and viscosity? Will planning be accelerated or retarded?

It is by obtaining answers to questions like these that the glass tank operator will learn about the mechanisms that go on in his furnace and learn to keep the variables in control.

• Five new assistants have been assigned to the Customer Service Department of the L.O.F. Glass Fibers Company, Toledo, was announced by Raymond Petersen, Customer Service Department Manager. They are Vernon L. Chriss, Richard E. Baginski, Douglas E. Hosley, Martin McCauley and John F. Wernert.

L. C. ROCHE NAMED A VICE PRESIDENT AT MARYLAND GLASS

L. C. Roche

Louis C. Roche was named vice president in charge of manufacturing of the Maryland Glass Corporation, at the meeting of the board of directors on October 12, 1956.

Mr. Roche received his A. B. degree in 1918 and M. A. degree in 1923 from Loyola College, Baltimore, Maryland. He served in the Navy with the rank of Ensign during World War I. In 1920 he entered the employ of the Emerson Drug Company as junior chemist. He was transferred to the Maryland Glass Corporation in 1927 to supervise the Chemical and Control Laboratory. In 1934 he was appointed factory manager and later on was elected secretary and member of the board of directors.

Mr. Roche has been a member of the American Ceramic Society since 1927 and was chairman of the Glass Division in 1938. He was chairman of the Labor Committee of the Glass Container Manufacturers Institute from its organization until two years ago when a full time director and chairman was appointed by the Institute. He still serves as chairman of the Joint Conferences between the manufacturers and the unions.

PITTSBURGH PLATE NAMES R. W. OATES TO NEW POSITION

Appointment of R. Wayne Oates as division controller, glass division for Pittsburgh Plate Glass Company has been announced by L. S. Williams, controller for the company.

Formerly a staff assistant in the plate glass division, Mr. Oates will be responsible for accounting activities in both the Glass Division and Fiber Glass Division. Mr. Oates joined Pittsburgh Plate in 1948 as an accounting trainee at Crystal City, Missouri. He later served there as cost accountant and supervisor of cost accounting before transferring to the Pittsburgh general office in 1955.

Mr. Oates is a graduate of the University of Illinois with a B. S. degree in accounting and a member of the National Association of Cost Accountants.

• The Chas. Taylor Sons Co., a subsidiary of National Lead Company, announces the appointment of Mexico Refractories Co. of Cuba as their exclusive representatives for the sale of *Taylor-made* special refractories in Cuba. Ing. Armando Basarrate is general manager of Mexico Refractories Co. of Cuba which is a subsidiary of Mexico Refractories Co., Mexico, Missouri. Their offices are in Havana.

TWO PROMOTIONS AT L-O-F EAST TOLEDO PLANT

A. W. Kleine

C. A. Miller

Charles A. Miller, Jr., who has been production manager at the East Toledo plant of Libbey-Owens-Ford Glass Company for six years, has been promoted to assistant plant manager, it was announced by C. W. Davis, executive vice president—production, and Henry M. Dodge, plant manager.

Mr. Miller will serve with Mr. Dodge, plant manager, and Henry Schult, first assistant plant manager, in the general management of the plant.

A native of Martinsburg, W. Va., he came to L-O-F in 1940 from Stevenson, Jordan & Harrison, industrial engineers. He was assistant manager of the plate glass plant before it was combined with the laminating plant in 1948 under the present general management. He served for a time as general superintendent of the plate factory before assuming duties as production superintendent of the combined plants.

Albert W. Kleine, who joined Libbey-Owens-Ford Glass Company at its plate glass plant in East Toledo in 1930, has been promoted from general superintendent of the laminating plant to production manager of the combined East Toledo plants, it was announced.

Mr. Kleine was affiliated with the assembly and plastic departments of the laminating plant for several years following his transfer to that plant in 1931. He has been general superintendent since 1950. He now succeeds Charles A. Miller, Jr.

The East Toledo plant is now the largest in the Libbey-Owens-Ford group and includes both complete plate glass and safety glass laminating plants.

D. KUHLMAN NAMED L-O-F PERSONNEL DIRECTOR

Dale Kuhlman, assistant personnel and safety director for Libbey-Owens-Ford Glass Company, has been promoted to personnel director, according to an announcement by L. G. Bryan, vice president.

Mr. Kuhlman succeeds Clarence A. Carson, Riverside Drive, Rossford, who will continue in an advisory position in L-O-F personnel work. Mr. Carson has been with the company since 1929.

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Fall Glass Division Meeting . . .

(*Continued from page* 612)

It is not definitely known what combination of Fe and S is formed in amber glasses and the three combinations of FeS, Fe_2S and Fe_2S_2 were all considered.

From the data studied one group of glasses appeared to follow a concept of FeS being present while another group followed the concept of Fe_2S_2 as being the most likely.

No specific conclusions were drawn but the paper definitely showed the desirability of further careful work on the subject.

A very enjoyable banquet was held Thursday night in the Bedford Springs Hotel dining room. Mr. J. Earle Duncan, Pittsburgh Plate Glass Company, Research Laboratories, Creighton, Pennsylvania, chairman of the Division presided over the dinner meeting in a very able manner. L. G. Ghering, trustee of the Glass Division, presented the Frank Forrest and the S. B. Meyer Jr. Award. The former was won by Dr. Morris Huggins, Eastman Kodak Company, Rochester, N. Y., for his paper "Structure of Glass." The latter was given jointly to R. Didtschenko, National Carbon Company, Cleveland, Ohio, and Professor Eugene C. Rochow, Harvard University for their paper, "Electrode Potential of Molten Silicates." Both papers were published in the *Journal of the American Ceramic Society*.

The Northwest Ohio Section of the American Ceramic Society announced that the Toledo Glass and Ceramics Award for 1957 will be given to Dr. Donald E. Sharp, Libbey-Owens-Ford Glass Company. The award will be made at the Toledo Club, Toledo, Ohio, on January 21, 1957.

H. R. Seelan, Manager, Color Kinescope Operations Department, Radio Corporation of America, Lancaster, Pennsylvania, gave an interesting talk "Electronics—An Opportunity for Ceramics." It was pointed out that the combination of ceramics and electronics has produced a most useful industry. The many useful achievements of electronics were reviewed and the role of glass in providing such products as X-rays, radios, television, household appliances, refrigerators, as well as apparatus for seeing, hearing and transmission of electrical power were emphasized.

In 1940, just 16 years ago, the electronics industry represented a 1.4 billion dollar industry. Today, 1956, it has grown to 10.7 billion dollars and it is predicted by 1965 it will have grown to 19 billion dollars. It was pointed out that the electronics industry got its start principally through the lamp and tube industry, today approximately 800 different radio tubes are manufactured.

A prediction was made that the future will see progress in the fields of dielectrics, phosphors, ferrites, transducers, transfluxers, etc. All of which will be aided and abetted by the glass industry and its improved products.

The many problems of color television were emphasized and the manner in which glass was helping solve some of these problems was pointed out.

An excellent demonstration was given by Mr. Hoyler, Radio Corporation of America, Lancaster, Penna., of how color has been produced on the television screen. The various steps of color transmission were illustrated and some excellent pictures were shown indicating what we may expect to attain in the future.

Sixty-six members took advantage of perfect fall weather to play golf on Thursday afternoon. Charles Gum, Ohio Lime Co. chairman, awarded the many prizes. Low gross of 79 was awarded to Bob Keady and many other prizes were given on the basis of handicaps. For those who did not play golf, four handsome door prizes were given to those whose names were pulled at random from a hat.

The ladies' program was handled by the following committee: Mrs. D. Owen Evans, chairman, Mrs. Fred L. Bishop, Mrs. W. H. Blenko, Jr., Mrs. Charles L. Cruikshank, Mrs. Hascall B. DuBois, Mrs. John C. Denison, Jr., Mrs. J. Earle Duncan, Mrs. J. Earle Frazier, Mrs. Charles E. Gum, Mrs. J. C. Keaney, Mrs. V. V. Kelsey, Mrs. Theodore Lenchner, Mrs. Howard R. Lillie, Mrs. John McCormick, Mrs. Fred W. Mowrey, Mrs. Eugene C. Ostrander, Mrs. Frank W. Preston, Mrs. Victor H. Remington and Mrs. R. Roger Robinson.

The ladies were pleasantly entertained by "Surrey rides", luncheons, bridge, canasta, etc.

On Friday October 12 a luncheon meeting was held of Committee C-14 (Glass) A.S.T.M. L. G. Ghering was chairman.

A business meeting followed the technical meetings and it was agreed to hold the next Fall Meeting of the Division at Bedford Springs on October 17-18, 1957.

• Koppers Company, Inc., of Pittsburgh, Pennsylvania, has been appointed a national distributor for Fiberglas roof insulation, it has been announced by Owens-Corning Fiberglas Corporation.

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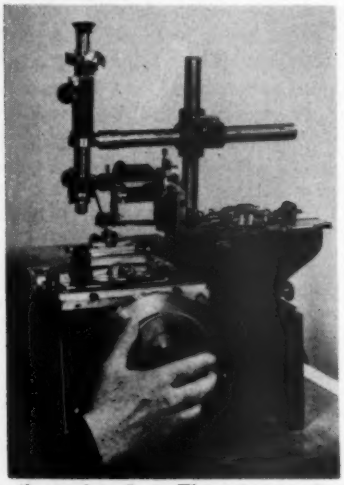
Precision Etching of Glass Scales . . .

(*Continued from page* 621)

ing methyl ethyl ketone, butly alcohol, and ethyl alcohol. The circle is then baked to increase the resistance of the developed resin coating to hydrofluoric acid. The best etching results are obtained with an aqueous mixture of hydrofluoric and phosphoric acids.

The Bureau also studied the effect of relative humidity on the deterioration of phenol-formaldehyde and cold-top enamel resists. Excellent results have been obtained with the resins developed for the photographic process. Graduation lines on the replicate circles are about 1 μ wider than those on the master circle.



Reticule - ruling machine designed for laboratory use at the *National Bureau of Standards.* This machine is also used to engrave test lines in experimental resists used in conventional etching and photoetching of glass scales. The machine places lines with an accuracy of ± 1 μ. The graduated drum adjoining the hand wheel is fitted with a vernier and may be easily read to 1 μ. The microscopic eyepiece and filar micrometer permit use of the machine as a highly accurate measuring instrument. The table attachment for holding reticules has longitudinal and crosswise adjustment as well as a divided circle with vernier and tangent screws for angular positioning.

Photomicrographs of master scale (above) and replicate glass circle (below) made from it for a theodolite. The process involves contact-printing with a light-sensitive phenolformaldehyde resist developed at the *National Bureau of Standards.* Both have been etched and filled with lead sulfide by a chemical deposition to increase legibility.

INDUSTRY LEADERS SPONSOR CONFERENCE TO EXPOSE CHALLENGING PROBLEMS WITH WINDOWS AND GLASS

Building problems rising from the extensive use of windows and glass in contemporary architecture will be critically examined at a conference scheduled for November 14 and 15 in the United States Chamber of Commerce in Washington, D. C., and sponsored by the nation's leading manufacturers of glass products, windows, and accessory devices, and their affiliated trade associations.

In order to completely and objectively review and appraise these problems and to effectively propose solutions, the meeting will be conducted as a technical forum bringing together the design professions and the industry for discussions of great interest to both.

TWO ORGANIZATION CHANGES AT CORNING GLASS

Two organization changes in the Research and Development Division of Corning Glass Works were announced by Dr. William H. Armistead, vice president and director of research and development.

Dr. Thomas Vasilos has been appointed manager of the ceramic research department. He succeeds Raymond O. Voss, who has been appointed supervisor of consumer product development. Dr. Vasilos joined Corning in 1955 as a research ceramist in the Research and Development Division.

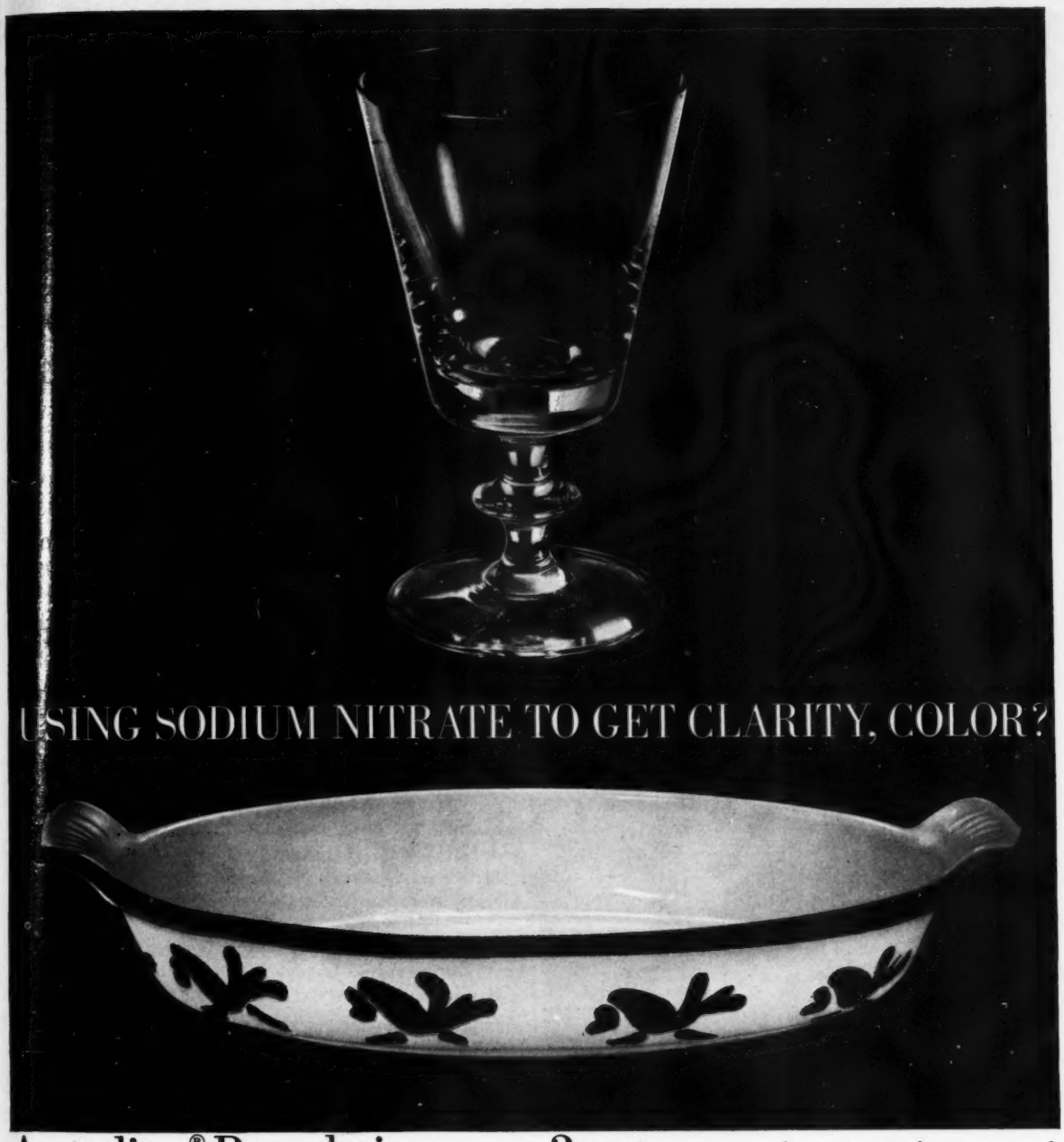
Mr. Voss joined Corning in 1942 as a chemist in the laboratory where he has since held positions as research associate and research supervisor. He has been manager of ceramic research since last February.

TOWER OF GLASS PLANNED BY CORNING

Plans to have a "tower of glass" constructed in New York City next year were announced by William C. Decker, president of Corning Glass Works.

The 28-story glass-sheathed office building will be erected on the southeast corner of Fifth Avenue and 56th Street. Corning Glass Works, Steuben Glass, Inc. and other firms directly or indirectly associated with Corning will occupy a substantial portion of the building's 365,000 square feet of office space.

One of the largest structures in the area, 717 Fifth Avenue will become the first building on upper Fifth Avenue to have its own lanscaped plaza and the first designed without setback. Architects are Harrison and Abramovitz who designed the United Nations group and other major projects that have featured glass as an architectural material.



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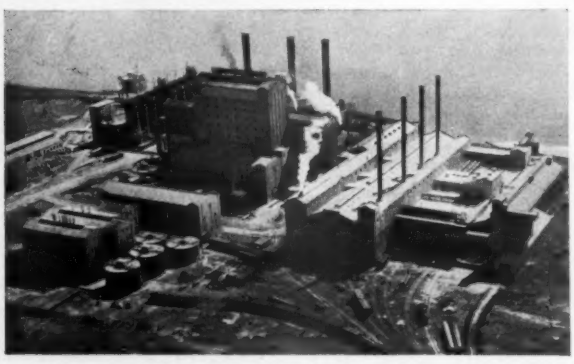
Milestones in Glass Progress

PHOTO COURTESY GLASS CONTAINER MANUFACTURERS INSTITUTE, INC.

1825 Early in the 19th Century, American glassmakers manufactured containers bearing likenesses of popular heroes of American history. This "memorial bottle" honors Lafayette, the renowned Frenchman who entered service on behalf of colonial independence in America in 1776.



1890 Michigan Alkali Company, now a division of Wyandotte Chemicals Corporation (North Plant, above), was founded by Captain J. B. Ford to supply Soda Ash to the glass industry. Wyandotte has grown up with glass. Today, as in the past, it is a working partner, supplying technical assistance and raw-material chemicals to those great companies marking milestones in glass progress.

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Michigan Alkali Division, Wyandotte Chemicals Corporation
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Inventions and Inventors . . .

(*Continued from page* 627)

firmly pressed together between the clamping bar and the platform to seal the assembly within the bag. After exhausting air from the bag through the vacuum lines 34, electric current will be supplied through the leads 37 (not shown) to the conductive rubber layers in the upper and lower walls of the bag. Upon completion of the preliminary sealing of the laminations the vacuum within the bag will be released, the valve 19 will be turned to raise the clamping bar. The pressed assembly may be withdrawn directly from the bag. The assembly may then be transferred directly to an autoclave for completion of the final sealings between the laminations.

There are 10 claims and four references cited in this patent. 1,872,693, Drake, Aug. 23, 1932; 1,960,480, Fraser, May 29, 1934; 2,054,864, Owen, Sept. 22, 1936, and 2,458,864, Lindsay, Jan. 11, 1949.

CERAMICS ENGINEER PROMOTED BY L-O-F TO CHARLESTON PLANT

Howard L. Miller, ceramic engineer with the technical division of Libbey-Owens-Ford Glass Company for 10 years, has been named manager of the technical control department of the Charleston, West Virginia, window glass plant, it was announced recently by A. G. Barton, manager of window glass production, and A. W. Swillinger, manager of the Charleston plant.

Mr. Miller joined the development department of Libbey-Owens-Ford in Toledo as a ceramic development engineer in January 1946 and on April 1, 1953 was promoted to ceramic engineer, furnace design and improvement section in the Engineering department.

He is a member of the Northwestern Ohio Section of the American Ceramic Society and has served the section as chairman and in other offices. He is also a member of the National Institute of Ceramic Engineers.

THREE PROMOTED AT O-I LIBBY GLASS PLANT

Promotion of three supervisors at Owens-Illinois' Libbey Glass plant, Toledo, has been announced by E. D. Dodd, plant manager.

Fred L. Sieloff was named supervisor of the Quality and Specification Department, and has been succeeded as supervisor of the Processing Departments by George W. Alexander. G. Curtis Carnahan was promoted to plant comptroller, succeeding Mr. Alexander.

Mr. Sieloff, a native of Toledo, has been with the Libbey plant since 1927. Mr. Alexander and Mr. Carnahan joined Owens-Illinois in 1933.

• American Nepheline Limited recently announced the appointment of C. M. Woodruff as assistant to H. R. Deeth, vice president and sales manager. His duties will include sales service work in Canada and quality-control standards for company products.

DONALD E. SHARP TO RECEIVE TOLEDO GLASS-CERAMIC AWARD

Dr. Donald E. Sharp, internationally known glass technologist and permanent vice chairman of the technical policy committee of Libbey-Owens-Ford Glass Company, Toledo, has been chosen to receive the 1957 Toledo Glass and Ceramic Award.

At the two-day fall meeting of the Glass division of the American Ceramic Society, Dr. L. G. Ghering, division trustee, announced the award offered "to accord recognition for outstanding scientific or engineering achievement in the glass and ceramic industries." He said it would be presented at a banquet on Jan. 21, 1957 at the Toledo Club in Toledo sponsored by the Northwestern Ohio section of the American Ceramic Society.

Dr. Sharp's election for the award was based on a long and distinguished career as a glass scientist, said Dr. Ghering. Joining Libbey-Owens-Ford in 1943, Dr. Sharp had served for several years as president of Bailey & Sharp Co., consultants to the glass industry, and as a member of technical staffs of several leading glass firms. He is the holder of several patents and has authored many scientific papers in glass technology.

He is a member of the International Glass Commission, a body which has devoted itself to study of efficiency of glass melting tanks, effects of iron oxide in glass, and theory and practice of glass annealing. He is also a member of the American Physical Society, the American Optical Society, a fellow of the Society of Glass Technology (British), fellow of the Royal Soc. of Arts (British), and a member of the Deutsche Glastechnische Gessellschaft.

A native of Corning, N. Y., Donald E. Sharp was born October 30, 1896, attending the University of Wisconsin, serving as an assistant in the physics department, and later studied at Carnegie Institute of Technology. From Alfred University in New York he received a professional degree in Ceramic Engineering in 1942. Lafayette College awarded him the honorary degree of Doctor of Science in 1952.

Dr. Sharp lived in Hamburg, N. Y., for 20 years. He served during 1930-31 as associate technical editor of THE GLASS INDUSTRY.

Francis C. Flint, technical director of Hazel-Atlas Glass Co., Wheeling, W. Va., was given the Toledo award last year.

Members of the Award committee, which considered nominations from a dozen states and Canada, include J. C. Coleman, Owens-Illinois Glass Co., chairman; K. C. Carnes, Toledo Engineering Co.; L. V. Gagin, L-O-F Glass Fibers Co.; Dr. A. E. Badger, L-O-F; J. F. Chambers, National Gypsum Co., Luckey, Ohio and Dr. Ghering, Preston Laboratories, Butler, Pa. Dr. Ralph K. Day, L-O-F, is general chairman of the award ceremony and banquet. A. H. Nieman, Ohio Lime Co., Woodville, Ohio, is chairman of the Award finance committee.

D. M. Palmer, of Delos M. Palmer & Associates, Toledo, is chairman of the arrangements committee handling reservations for the award banquet.

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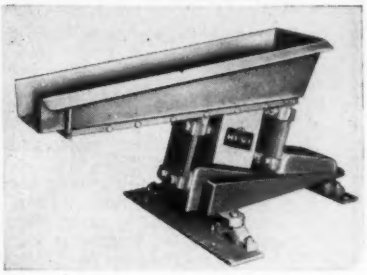

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